

NATIONAL SMOKE ABATEMENT SOCIETY

President : H. A. DES VOEUX, M.D.

Chairman and Hon. Treasurer : ALDERMAN WILL MELLAND, J.P.

Hon. Advisory Secretary : Sir LAWRENCE W. CHUBB.

General Secretary and Editor : ARNOLD MARSH, M.Sc. Tech.

Vice Presidents :

H.R.H. THE PRINCESS LOUISE, DUCHESS OF ARGYLL.

THE EARL OF STAMFORD.

LORD NEWTON.

VISCOUNT CECIL OF CHELWOOD.

THE RT. REV. THE LORD BISHOP OF LONDON.

THE VERY REV. THE DEAN OF WELLS.

THE VERY REV. THE DEAN OF CANTERBURY.

SIR NAPIER SHAW, Sc.D., F.R.S.

SIR THOMAS BARLOW, BART, K.C.V.O., F.R.S., M.P.

SIR OLIVER LODGE, F.R.S., D.Sc.

J. W. GRAHAM, D. Litt., M.A.

PETER FYFE.

W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.

E. D. SIMON, M.P.

Coun. W. E. HINCKS, J.P.

Dr. J. JOHNSTONE JERVIS, M.D., D.P.H.

THIRD ANNUAL CONFERENCE

TO BE HELD AT

LIVERPOOL

September 18th, 19th, 20th

1931

PROGRAMME

PROGRAMME



FRIDAY, September 18th—

- 8 p.m. RECEPTION by the Lord Mayor of Liverpool (Alderman Edwin Thompson) at the Town Hall. (*See note page 4*). Invitations will be sent by the Lord Mayor to those intimating their intention of being present at the Conference.

SATURDAY, September 19th—

- 9-45 a.m. In the Lecture Theatre, The School of Hygiene.

ANNUAL GENERAL MEETING.

Chairman: The President.

AGENDA.

1. To approve the Minutes of the previous Meeting.
2. To receive the Annual Report.
3. To receive the Annual Statement of Accounts.
4. Election of President.
Vice-Presidents.
Hon. Treasurer.
Council.
Executive Committee.
5. Any further business.

- 11 a.m. CONFERENCE. FIRST SESSION.

Chairman: Alderman WILLIAM MUIRHEAD, J.P.

“The Progress of the Electrical Grid”

By Robert Blackmore, Esq., M.I.E.E. of the Central Electricity Board.

Discussion.

- 12 noon. “Some Notes on the Production and Use of the new Smokeless Fuel ‘Dryco’ in Liverpool”

By Ralph E. Gibson, Esq., M.Inst.C.E., M.Inst.Gas E., of the Liverpool Gas Company.

Discussion.

Both Papers will be illustrated by Lantern Slides.

2-30 p.m. MOTOR TOUR. (By kind invitation of the Liverpool Public Health Committee). Visits will be paid to the Housing Estates, the new Clarence Dock Power Station and other places of interest. (*See note on page 4*).

8 p.m. An informal meeting will be held in the Adelphi Hotel.

SUNDAY, September 20th—

11 a.m. In the Lecture Theatre, School of Hygiene.

CONFERENCE. SECOND SESSION.

"Regional and Statutory Smoke Abatement Committees." Several short papers and communications concerning the development and activities of the several joint committees, by members of the Committees will be read, and will be followed by a discussion upon the various problems with which these Committees are concerned. The papers will be as follows:

"The Sheffield, Rotherham and District Smoke Abatement Committee" by Councillor W. Asbury.

"The West Riding of Yorkshire Regional Smoke Abatement Committee" by Dr. J. Johnstone Jervis, M.D., D.P.H.

"The Manchester and District Regional Smoke Abatement Committee" by Dr. James Bennett, J.P., M.O.H.

"The Greater London Joint Smoke Abatement Committee."

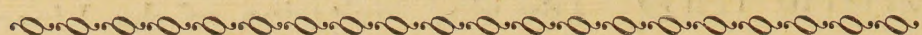
"The Midlands Joint Advisory Council for Smoke Abatement."

12-15 p.m. A Demonstration of the Apparatus used for the measurement of atmospheric impurities (kindly loaned by the Department of Scientific and Industrial Research), by W. H. Roberts, Esq., M.Sc., F.I.C., City Analyst, Liverpool (Member of the Standing Conference of Co-operating Bodies for the Investigation of Atmospheric Pollution).

3-30 p.m. At the Adelphi Hotel.

COUNCIL MEETING. (For elected members of the Council, members of the Executive Committee and representatives appointed by affiliated local authorities and associations).

CONFERENCE ARRANGEMENTS.

**Hotel.**

The Conference Headquarters will be the ADELPHI HOTEL, Liverpool. Members in reserving their rooms should mention that they are attending the Society's Conference, in order to obtain the special terms arranged. These are :

Dinner, Friday evening to Breakfast, Monday morning, £3/2/-
Bed, breakfast, luncheon and dinner, per day - - - £1/2/-
(Kindly note that rooms will not be reserved by the Society on behalf of members, as hitherto). Names of other hotels will be forwarded if required.

Reception.

Those desiring to receive an invitation to the Lord Mayor's Reception on the Friday evening should indicate this on the reply-form, which should be returned as soon as possible.

**Motor
Tour.**

It is hoped that all attending the Conference will avail themselves of the opportunity of seeing the places of interest that this Tour will afford. Please state on the reply-form whether you wish to participate.

**Conference
Hall.**

The Conference will be held in the Lecture Theatre at the School of Hygiene, Mount Pleasant, which is about five minutes walk from the Adelphi Hotel and the Central Station.

**Liverpool
Official
Handbook.**

A limited number of copies of the Official Handbook to Liverpool will be available to members upon request at the Conference Office, Adelphi Hotel.

**Conference
Fee.**

A nominal registration fee of 2/6 per member or delegate will be made in order to defray some of the Conference Expenses.

**Date for
Reply.**

The Secretary will be obliged if those intending to be present would return the accompanying reply-form as soon as possible, and in any case **not later than September 14th.**

**Further
information**

Any other information may be obtained from the Society's Central Offices, 23 King Street, Manchester, up to September 17th, and afterwards at the Conference Office, Adelphi Hotel, Liverpool.

23 KING STREET,
MANCHESTER.

ARNOLD MARSH
General Secretary.

B 622
C 311

THE NATIONAL SMOKE ABATEMENT SOCIETY

The Production and Use of the
New Smokless Fuel "Dryco"
in Liverpool

BY

R. E. GIBSON

M. INST. C.E., M. INST. GAS E.

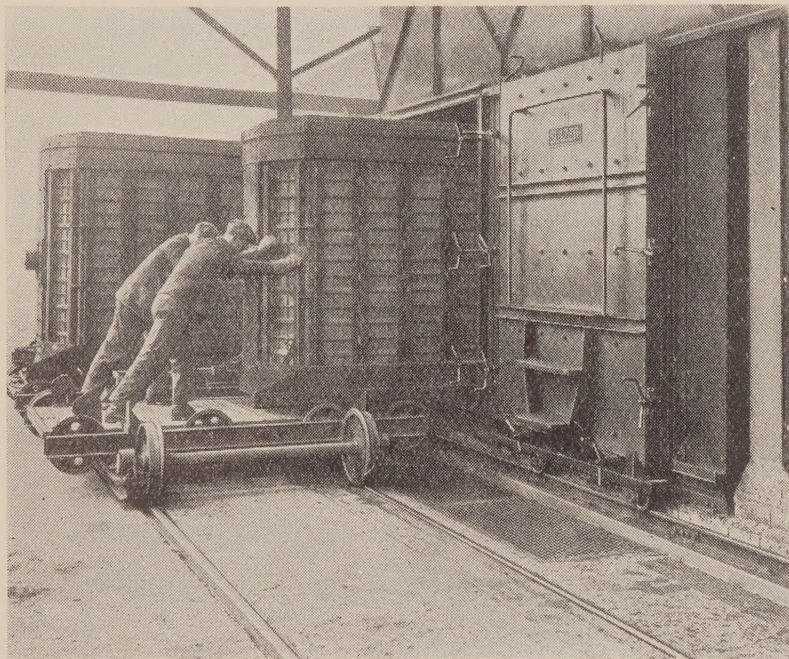
A Paper read at the Annual Conference held at
Liverpool on September 19th, 1931 and reprinted from
The Journal of the National Smoke Abatement Society
23, King Street, Manchester

Some Notes on the Production and Use of the Smokeless Fuel "Dryco" in Liverpool.

By R. E. GIBSON, M.INST.C.E., M.INST. GAS E.

Introductory.

It is satisfactory to note that as a result of the persistent advocacy of smoke abatement by this Society and its predecessors, public opinion is being slowly but surely formed in favour of the use of smokeless fuel. That there is wide scope for the extension of the sale of such fuel is obvious when one is informed that some 23% of the coal used in this country, amounting to 40 million tons, is still used in the raw state for domestic purposes. Many attempts have been made to produce smokeless fuels which would find a ready sale in place of raw coal but only, so far, with very limited success. For certain purposes gas coke and oven coke are suitable but for various reasons they do not give entire satisfaction when burnt in the open domestic grate. The advocates of low temperature carbonization have for many years devoted much time, money and energy in producing low temperature smokeless fuels. While their efforts have been successful in producing fuels which in most respects meet the requirements, they have so far unfortunately failed to make satisfactory progress on a large scale on account of the fact that the processes have been difficult to establish on a satisfactory commercial basis.



COKE CONTAINER ENTERING SULZER CHAMBER.

The Gas Industry and Low Temperature Carbonization.

The attitude of the Gas Industry towards low temperature carbonization has in some quarters met with adverse criticism. While the Gas Industry is more favourably situated for taking up low temperature carbonization than any other industry it has appeared to be apathetic and apparently unwilling to recognise the advantages of low temperature systems. This view, however, is far from being correct as the Gas Industry has for a long time realised the importance of the production of a good smokeless fuel. It has been careful to satisfy itself, however, as to whether the proposals put forward gave

promise of being sound commercial propositions. Several low temperature processes have been and are being tried out by Gas Undertakings and if found successful from the commercial point of view, as well as that of efficiency, they will no doubt be retained and extended. If however, equally good results can be obtained by high temperature carbonization with its greater yield of gas, there would appear to be little hope of Gas Undertakings adopting low temperature systems extensively in preference to high temperature carbonization. The Gas Industry is primarily concerned with the production of gas and any process which cuts down the quantity of gas produced, whether in cubic feet or therms, is naturally looked upon with disfavour unless there are compensating advantages. The special fuel and the liquid products produced must realise prices sufficiently high to make the process worth while. On the other hand the extended sale of the smokeless fuel produced must depend very largely on its price in relation to that of coal. The Gas Industry is in a favourable position to utilize all the gas made and has existing facilities for dealing with the by-products.

High Temperature Carbonization.

The Gas Industry has already made a great contribution to the solution of the smoke problem by providing by means of High Temperature Carbonization, an excellent gaseous fuel for cooking and heating and a smokeless solid fuel, gas coke, which for many purposes is very satisfactory. Gas Fires are clean, convenient, efficient and quite as cheap to run as coal fires for intermittent use, but for continuous or all-day use the coal fire costs less. Since large numbers of people in this country have still a deeply-rooted affection for the open coal fire, it is necessary to provide at reasonable cost a smokeless fuel which will give the cheerful effect of coal without its attendant evils of smoke, filth and dust.

It has been proved beyond doubt that the Gas Industry can, if it will, produce such a fuel in the plant in common use for the manufacture of town gas. In this connection one must bear tribute to the good work done by Mr. John Roberts, a pioneer in the production of a freely burning fuel by carbonizing blends of caking and non-caking coals.

Mr. Roberts conducted experiments on a working scale at Ramsgate with Intermittent Vertical Retorts and produced a fuel named "Homite" which was very satisfactory when used in open fires. His process, however, was not carried out quite under the ordinary conditions generally obtaining in Gas Works. Mr. Roberts foresaw the possibilities however, and predicted that the kind of fuel required for the domestic grate could be produced by high temperature carbonization and by the ordinary methods generally in use on Gas Works. That prophecy has been fulfilled. The Liverpool Gas Company after carrying out research extending over many years has produced a new fuel made by high temperature carbonization known by the registered name of "DRYCO," which gives excellent results and can be sold at a price that can easily compete with that of house coal.

Qualities Desirable in a Domestic Fuel.

The qualities to be desired in a good domestic fuel for use in the open grate may be stated as follows :—

1. The fuel must be easily ignitable.
2. It must not take long to reach its maximum heat radiating power.
3. It must give a good heat radiation and must be capable of maintaining its heating power for as long a period as possible, giving a bright fire almost to the end.
4. It must be capable of burning away so that the unconsumed fuel left in the grate at the end shall be reduced to a minimum.
5. The ash left in the grate must be small in quantity and not of that light dusty kind which adheres to the surface of the fuel and is blown into the room, but must be the sort that will fall into the ashpan and cause a minimum of nuisance.
6. The fuel must be smokeless.
7. It must give a cheerful glow and some flame to impart a lively appearance to the fire.
8. It must be clean to handle.
9. It must be reasonable in price.
10. It must be sufficiently robust in structure to stand a reasonable amount of transport and handling.

It is claimed that "Dryco" possesses all these qualities when burnt in an open grate. This result has been achieved after lengthy research and the surmounting of many difficulties.

The fuel is now being made on a commercial scale at the Eccles Street Works of the Liverpool Gas Company, where new blending and dry-cooling plant has been installed for the purpose. This Plant has been working continuously since January last.

Summary of Research Work.

A brief summary of the research work carried out resulting in the production of Dryco may be of interest. Much valuable work had already been done on the production of coke and smokeless fuel by the Fuel Research Board, the Leeds University and others. The research at Liverpool has been carried out from the practical standpoint of making use of ordinary methods, existing gas making plant and under local conditions. Investigations were carried out in at least four different directions, viz :—The selection and blending of suitable coals ; the study of temperature conditions ; methods of dry cooling ; and the question of sizing or grading.

The research involved both chemical and mechanical problems.

In conducting the investigations it was stipulated generally that :—

1. The coals used must be easily obtainable and that they should be used in the state in which they were received from the Colliery, that is without any additional washing, screening or grinding.
2. That carbonization must be carried out at high temperatures as generally used in Gas Works and without material reduction in the make of gas per ton.
3. The Fuel produced must be dry cooled and graded to the size most suitable for use in a domestic grate.
4. That the graded fuel must be capable of being easily ignited in the ordinary way with wood and paper.
5. That the ash content should be reasonably low and of the kind that would not adhere to the surface of the fuel but would fall into the ashpan.

A long series of experimnts were made by Mr. H. H. Thomas, B.Sc., at Garston on the properties of various coals with a view to their suitability for blending, the effect of the size of the particles, the temperature and period of carbonization and tests of the solid residuals therefrom for ignitability, rate of burning, strength, etc.

By process of elimination, the coals and methods of treatment found most suitable for giving the required results under high temperature carbonization were selected for further experiments.

Some of the results of these are shown in Table I.

TABLE I.
TESTS OF FUEL
PRODUCED FROM BLENDS OF A CAKING COAL WITH A NON-CAKING COAL.

I	Cak- ing Coal %	Non- Cak- ing Coal %	Temp. of Carbonization		Period of Car- boniza- tion Hours	Analysis of Fuel Produced				Shatter Tests of Fuel					Gas required for ignition
			Com- bus- tion Cham ber o C	Re- tort o C		Mois- ture	Vol. Mat.	Car- bon %	Ash %	As taken from Retorts					
										On 2"	2" on 1½"	1½" on 1"	1" on ½"	Thro ½"	
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
A	40	60	..	1050	9.0	3.58	2.72	86.66	7.04	70.0	13.0	8.0	5.6	6.4	4
B	50	50	..	1060	9.0	2.82	2.58	84.98	9.62	64.0	16.0	8.0	7.6	6.8	6
C	50	50	..	1100	9.5	2.64	1.46	89.02	6.88	62.0	14.0	10.0	6.0	7.5	6
D	40	60	..	1060	9.75	3.40	2.9	86.88	6.82	66.0	14.0	7.0	12.0	6.3	6
E	50	50	1380	930	10.0	1.48	1.12	90.28	7.12	64.0	18.0	8.0	6.4	5.0	20
F	60	40	1400	1070	10.0	1.48	1.92	89.64	6.96	58.0	17.0	11.0	5.9	8.0	20
G	66	34	1370	950	8.0	3.64	2.76	87.25	6.35	68.0	14.0	6.0	6.3	5.3	4
H	60	40	..	1030	10.0	2.44	1.76	88.76	7.04	66.0	12.0	9.0	7.8	5.5	8
J	60	40	..	1020	10.25	7.0	2.51	84.24	6.25	54.0	18.0	12.0	12.0	6.1	8

A large number of different fuels made under the conditions that were found most suitable were tested in an open grate with apparatus for ascertaining the radiation, relative ignitability, etc. Each fuel to be tested was broken and graded through 2in. mesh and over 1in. mesh and 12lbs. of the fuel placed in the grate. For the purpose of testing the relative ease of ignition, a gas burner was used and the gas required to ignite the fuel was measured by meter. To ascertain the relative radiating power of the fuel and the time taken to reach the point of maximum radiation, galvanometer readings were taken every 15 minutes. The fire was replenished when the fuel was level with the top bar of the grate, enough fuel being added to restore the original level. Each test was run for six hours and during that time the grate was replenished twice. After the final readings had been taken the fuel was gathered in the middle of the grate and allowed to burn out. The ash and unburnt fuel were afterwards collected and weighed.

In this way much valuable information was obtained which may be summarized as follows :—

1. Relative ease of ignition.
2. Time taken to reach point of maximum radiation.
3. Radiation curve for the period of test.
4. Average radiation.
5. Power to pick up after replenishing.
6. Weight of ash and unburnt fuel left.

Tests were also made, using wood and paper for lighting.

It was found that if the fuel would ignite with 4 cu. ft. of gas, it could with certainty be lighted fairly easily with wood and paper. It was noticed that the fire reached its maximum radiation sooner when lighted with wood and paper than when gas was used and turned out after ignition had taken place.

The Shatter tests were helpful in showing the relative strength of the fuel to stand handling and transport.

Further tests were made to ascertain the most suitable grading or size of the fuel. One batch of the same fuel was graded to the following sizes :— $2\frac{1}{2}$ in., 2in., $1\frac{1}{2}$ in., and $\frac{1}{2}$ in. There were remarkable differences in the behaviour of these grades of fuel especially as regards ignition. The $2\frac{1}{2}$ in. size refused to ignite with 20 cu. ft. of gas but lighted fairly easily when the bottom of the grate had first been covered with small fuel and then with the $2\frac{1}{2}$ in. fuel added. The radiation however was comparatively poor and it took a long time to reach the point of maximum radiation. In the case of the 2in. size ignition was obtained with 6 cu. ft. of gas, the maximum radiation was higher but was reached in a longer period of time. The $1\frac{1}{2}$ in. size required $4\frac{1}{2}$ cu. ft. of gas for ignition and the 1in. and $\frac{1}{2}$ in. sizes only 4 cu. ft., the more densely packed fuel offering a greater surface to the gas flame. When the gas flame was turned out, however, the rate of combustion decreased. The best radiation figure was reached with the 2in. grade.

After careful study of the results it was decided that the new fuel should be graded to pass through 2in. mesh and all particles passing through $\frac{1}{2}$ in. mesh should be rejected.

It was found that the presence of moisture in the fuel greatly retarded ignition, while the presence of volatile matter, although not essential, assisted ignition.

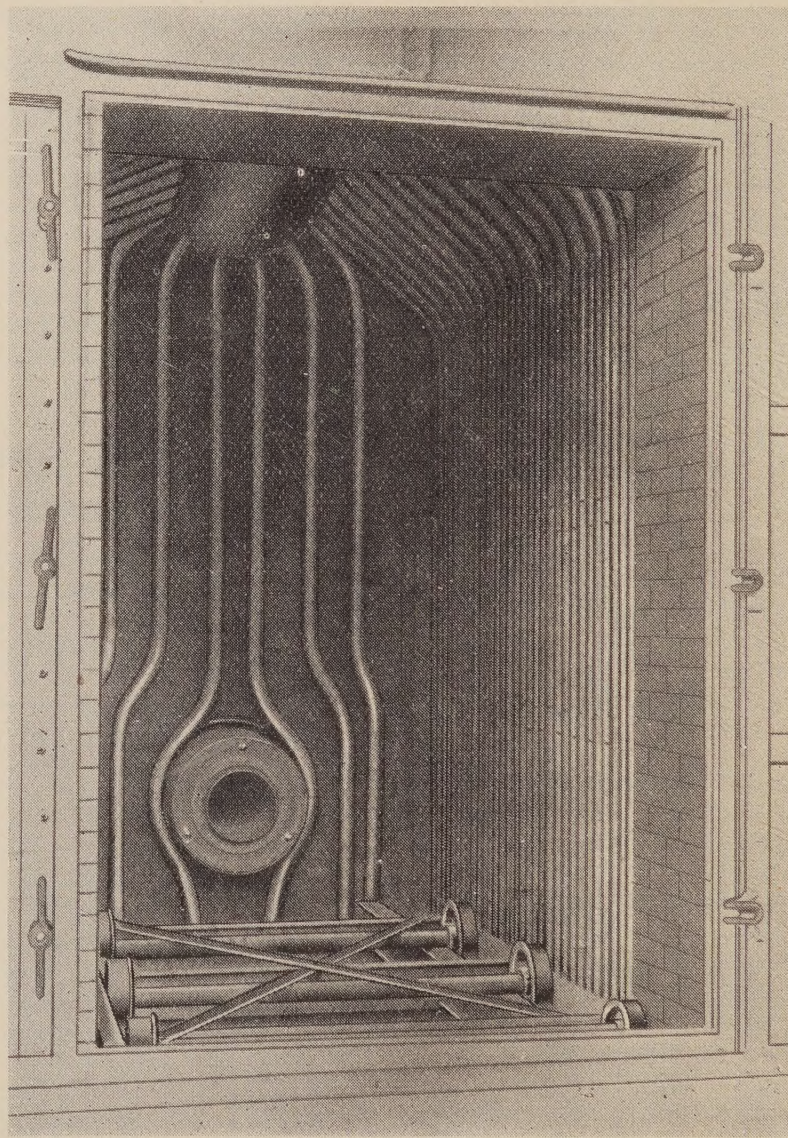
Referring to Table I., it will be seen that the volatile matter present in the fuel was not a determining factor as regards its ignitability. For instance, in test "C" a

50/50 mixture was carbonized at 1100% C in $9\frac{1}{2}$ hours and the volatile matter in the fuel was only 1.46% and yet it ignited with only 6 cu. ft. of gas, whereas a similar mixture in test "F" carbonized at a slightly lower temperature (1070% C) for 10 hours, produced fuel containing 1.92% volatile matter but required 20 cu. ft. of gas for ignition. The tests indicate that careful control of the heats and the period of carbonization are important factors, and this has proved to be so in practice on a larger scale.

All the fuels referred to in the Table gave good radiation results. The Shatter tests showed that all the fuels were reasonably strong and suitable for handling and transport even when as much as 60% of the non-caking coal was used.

Blending.

The finding of a satisfactory method of intimately mixing two or more coals on a working scale was not so simple a matter as it at first seemed, especially when the coals to be mixed were different in size and physical condition. It was realised that while pulverizing the coals before mixing would undoubtedly be an advantage, additional expense would be incurred which should be avoided if possible. It was of course necessary to provide some means of varying the proportions of the coals to be blended.



INTERIOR OF SULZER DRY-COOLING CHAMBER SHOWING TUBES OF STEAM BOILER.

Several mechanical devices were considered and two methods were tried on a practical working scale. The first plant erected at Garston consisted of two hoppers arranged side by side with bottom openings leading into a trough containing two screw conveyors, one of them with a right hand thread and the other with a left hand thread, conveying the two coals to be mixed to a central discharge shoot leading to a gravity bucket elevator. By altering the gear ratio the relative speeds of the two screw conveyors could be varied and the proportions of the two different coals definitely fixed in any required ratio.

The other device and the one which is now in operation at the Eccles Street Works consists of two discs rotating in horizontal planes, one above the other, fitted with ploughs and adjustable feeding shoots. At each revolution of the discs definite quantities of the coals are swept into a common shoot fitted with deflecting plates for further assisting in mixing the two qualities. The quantity of coal passing from each disc can be regulated by raising or lowering the feeding shoot delivering the coal to the disc. Tests have proved that the coals are intimately mixed and the product uniform in quality. The latter method is less costly than the other and has never failed, whereas the first method described, while quite satisfactory when care is taken, has been known to fail due to the coal hanging up in one or other of the hoppers and so failing to feed one of the coals into the conveyor.

Dry Cooling.

The first plant installed by the Liverpool Gas Company on a working scale for cooling incandescent coke without contact with water was erected at the Linacre Gas Works in 1912. At that time it was realized that excessive moisture lowered the heating value of the coke considerably, while contact with water when the coke was in a highly heated state had a disintegrating effect, tending to form breeze. Briefly, the plant consisted of twin steel containers (the two compartments being fixed one above the other), approximately the same in section as the retort but half its length and closed at one end. The container, suspended from the travelling carriage of an overhead transporter, was placed before the retort in a horizontal position and the red hot coke was pushed into it. The container was then turned on its trunnions into a vertical position, the upper end being automatically closed by a heavy lid, and then transported to a series of cooling chambers, each container being lowered into a separate cooling chamber. Water was then circulated by means of a pump around the container. At the end of an hour the coke was sufficiently cool to be discharge and the container was then withdrawn and discharged by tipping. This plant worked for some years but they heavy containers were found to be rather awkward to handle and the repairs were heavy.

When new Coal Gas Works were constructed at Garston in 1921 the opportunity was taken to instal another dry cooling plant in which the container and cooling chamber were combined.

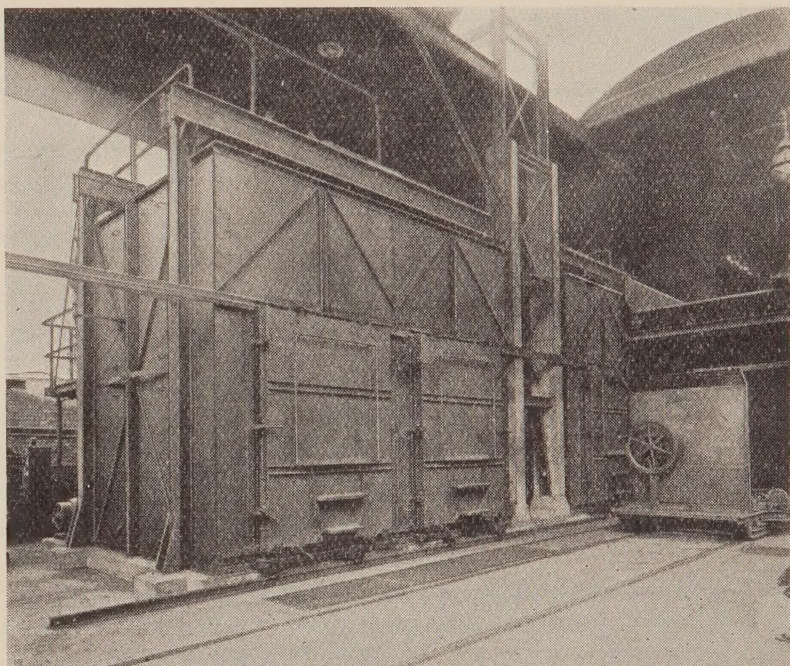
The red hot coke was run into the chamber directly from a "G.N." Coke Handling Machine, the top door was then shut and water was circulated round the walls of the chamber as in the case of the original plant at Linacre. The Coke when sufficiently cool was discharged from the bottom door into a Telpher skip. (This plant was described and illustrated in the Author's paper read before the Institution of Gas Engineers in 1924.).

The plant at Garston was in continuous use from 1922, except during repairs, up to a short time ago.

When it was decided to adapt the Eccles Street Gas Works for the production of "DRYCO" the question of dry-cooling had to be further considered. Messrs. Sulzer Bros. of Winterthur had brought out a new method of cooling which at the same time made use of the heat from the incandescent coke to generate steam. Plants on this system were erected at Burnley and at Glasgow.

The essential features of these plants were :—

- A large firebrick-lined container ;
- A hoist for lifting the red hot coke into it ;
- A water tube boiler, and
- A fan with connections to the container and the boiler.



EXTERIOR VIEW OF SULZER DRY-COOLING CHAMBERS.

The plant was operated as follows :—

The red hot coke having been deposited in the container and the door closed inert gases formed inside the container were drawn by means of the fan through the boiler and re-circulated over and over again until the heat from the coke had been transferred to the water in the boiler for the production of steam. After inspection of the plants at Burnley and Glasgow and also other installations on the Continent embodying further improvements it was decided to instal at the Eccles Street Works an improved form of Sulzer Cooling Plant in which the separate cooling chamber and the hot coke hoist were eliminated. In this system the red hot fuel is placed in a large container which is then run on rollers into the interior of a water tube boiler provided with a tightly fitting door. Inert gases are circulated by a fan through the red hot fuel and around the water tubes of the boiler until at the end of eighty minutes the fuel is sufficiently cool to be taken out. At the end of the period the fan is stopped, the door is opened, the container drawn out of the chamber and another container filled with incandescent fuel is inserted. The plant will produce nearly 1,000lbs. of steam per ton of fuel cooled. The steam is used for generating power on the works. The container full of cooled Dryco is hoisted, transported and tipped into the hopper of the breaking and screening plant.

Preparation of Dryco for Distribution.

After the "Dryco" has been cooled in a Sulzer Coke Cooling Plant, it is broken down to 2in. size by means of a "Nelson" Breaker, in which the

breaking elements are in the form of pricker rings made of Manganese steel. It is then passed over a "Roisin" Screen which eliminates all the fines $\frac{1}{8}$ in. and under. The Roisin Screen consists of a series of rollers with equal spaces between, corresponding to the size or grade of the breeze to be separated. Most of the rollers have coarse threads on their surfaces but, after every four rollers is placed a plain roller, the four succeeding rollers having threads of a different hand. This arrangement gives the peculiar motion to the fuel which is the special feature of the system, since in addition to each piece being continually and gently turned over it is also moved from side to side. The roller shafts work in self aligning pedestals with "Tecalemit" lubricators. After passing over the Roisin Screen the "Dryco" is passed into

a storage hopper from which it is drawn as required for bagging. In order to properly grade the fuel and take out any further fine breeze which may have been formed in passing through the hoppers, the "Dryco" is drawn from the Storage Hopper into an "Excelsior" Screen, from which the bags are filled. Each bag is marked in large letters with the name "DRYCO" and is weighed to contain 1 cwt. After being sealed the bags are placed on lorries for immediate delivery.

Comparison with Other Fuels.

In Table II. Dryco is compared with a good domestic coal, a well known low temperature fuel and a vertical gas coke.

TABLE II.

1	2 Gas Required to Light	3 Maximum Radiation during first 2 hours	4 Time Taken to reach Maximum Radiation	5 Average Radiation over whole period of Test	6 Ash and Fuel remaining after fire had gone out
	C. ft.	Galvanometer Reading	Minutes	Galvanometer Reading	%
"Dryco"	4	105.0	75	93.5	10.2
Low Temperature Fuel ..	3	82.6	75	81.1	9.9
Coal	2	63.6	120	66.1	11.7
Vertical Coke	6	87.0	120	62.0	12.1

It will be seen that Dryco gave the highest degree of radiation (105) in the first period and reached that point in 75 minutes, whereas the low temperature fuel only reached 82.6 in the same period of time, the other fuels being much inferior both from the point of view of maximum radiation and the time taken to reach that maximum. The coal fire gave off luminous flames but was black at the top and a much lower maximum radiation (63.6) was reached than in the case of the other three fuels. The Dryco and the low temperature fuel after replenishing, in the second period reached maxima of 114.6 and 113 in 45 minutes and 60 minutes respectively, while the coal reached 86.3 in the second period.

In column 5 the average readings for radiation for the whole period of the test, taken every 15 minutes, showed

that Dryco was superior to the low temperature fuel and much better than the coal and the vertical coke. The percentage of ash and fuel remaining in the grate after the fire had been allowed to go out did not show much difference. The best figure was 9.9% in the case of the low temperature fuel, Dryco being only slightly more (10.2%). The Dryco containing 2% of volatile matter, was entirely smokeless but the low temperature fuel, containing 11.7% volatile matter, gave off a little smoke when it was lighted and also when it was replenished. As was to be expected the low temperature fuel ignited more readily than Dryco but it was found that when only 4 cu. ft. of gas was required for ignition, Dryco would readily ignite with paper and wood, a good fire being obtained in a shorter time than when gas was used. A typical test of the Dryco now being made is given in Table III.

TABLE III.

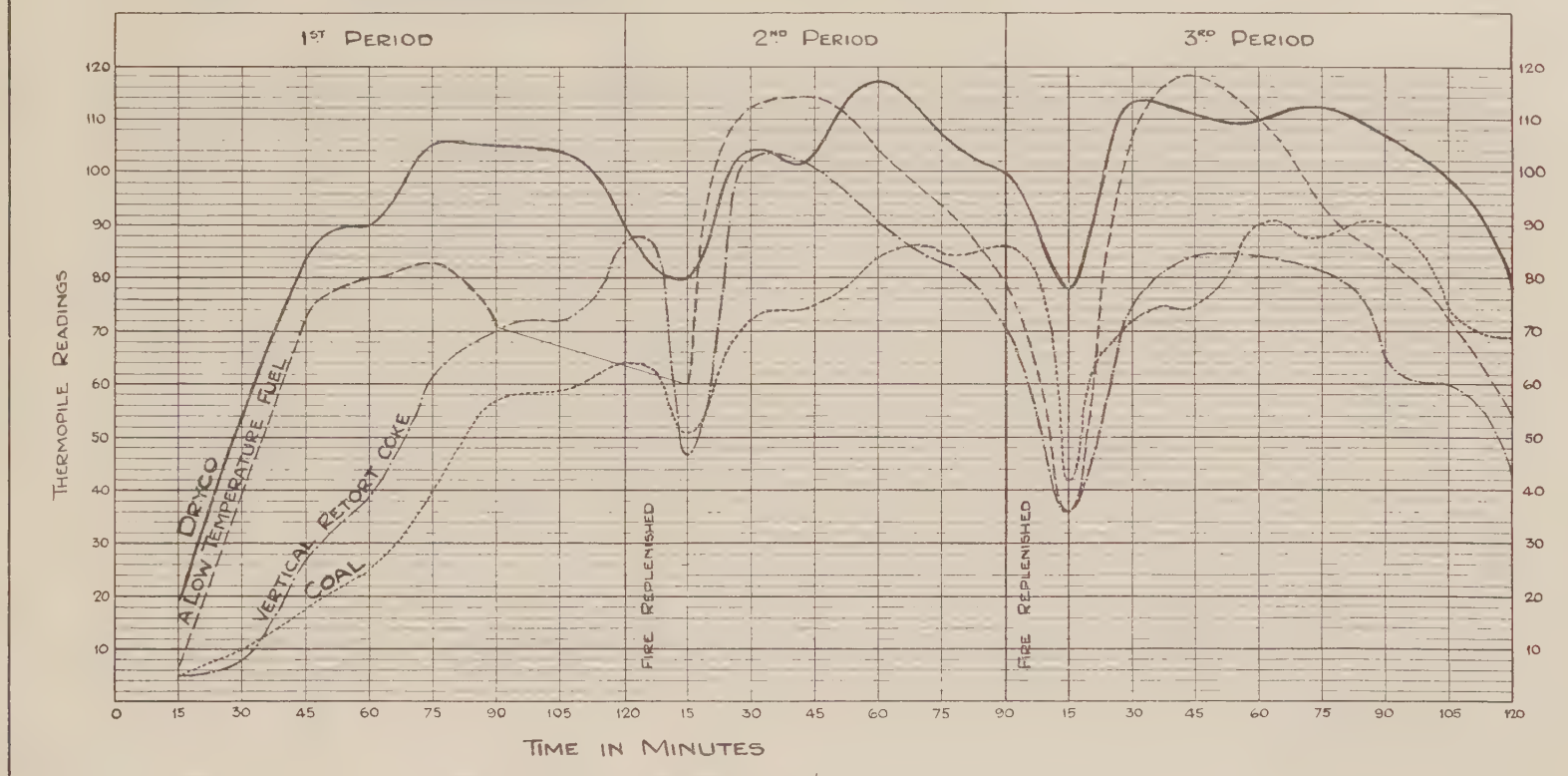
1 Gas to Light Fire	2 Time Taken to reach Maximum Radiation 1st Period (2 hours)	3 Maximum Radiation during 1st Period (2 hours)	4 Maximum Radiation in whole of Test Period	5 Average Radiation over whole period of test	6 Ash and Fuel remaining after fire had gone out
C. Ft.	Minutes	Galvanometer Reading	Galvanometer Reading	Galvanometer Reading	P. Ct.
3	80	95	120*	89.4	10.7

*Pointer went beyond the Scale of the Galvanometer.

After the first replenishment the fire reached a radiation figure of 92 in 15 minutes and 108 in 30 minutes. It may be claimed that these results are

extraordinarily good and especially when it is noted that the fuel contained only about 2% of volatile matter.

DIAGRAM SHOWING COMPARATIVE HEAT RADIATION OF DRYCO
AND OTHER FUELS



AVERAGE OF THERMOPILE READINGS	
DRYCO	94.05
COAL	60.50

Dryco, in Use, Its Advantages.

Large numbers of users of Dryco have expressed appreciation of its good qualities and have continued to use it in place of raw coal. They have found that it lasts longer, weight for weight, although the fire may require feeding at rather more frequent intervals. It is graded to a fairly uniform size, is clean to handle, and produces a hot fire of much greater heating power than coal. Dryco can be lighted with paper and wood in the ordinary way and within a quarter of an hour a good body of hot fuel can be obtained. It has a cheerful appearance due to the brightly glowing fuel and the short flickering flames appearing on the surface.

Another important feature is that the fire may be allowed to get low and will pick up again quickly when replenished. The fire remains bright almost to the end if allowed to die down and the amount of ash left is small in quantity and is not of that light powdery nature that will adhere to the fuel or fly about the room but will fall into the ashpan and cause a minimum of nuisance. The fuel is absolutely smokeless, it is cheaper than coal, but will last longer for it is twice the bulk of coal, being much lighter per cubic foot. It contains no moisture and the sulphur content is much less than in coal. The fuel being sootless, chimney sweeping and flue cleaning are eliminated and the atmosphere is kept clear so that the full effect of the sun's rays may be enjoyed.

Dryco has been found very satisfactory not only in open grates of various kinds but also in kitchen ranges, slow combustion stoves and hot water boilers. During the past nine months a grate has been in constant use at the Showrooms of the Liverpool Gas Company for demonstrating the burning of Dryco. The fire has attracted the attention of large numbers of people. Hundreds of orders has been obtained from those who have seen it in operation. The grate of this fire slopes

downwards towards the back and is particularly suitable for this class of fuel. Dryco will, however, burn well in any type of grate.

As Dryco is smokeless some people have erroneously thought that it might be used in a fireplace where coal could not be used on account of down draught. This is of course is an entirely mistaken idea as in both cases the products of combustion would go into the room instead of up the chimney.

The best way of lighting a Dryco fire with paper and wood is as follows :—

Paper is placed in the bottom of the grate, and three or four pieces of wood kindling are laid on this, parallel with the bars or front of the grate. On this about the same number of pieces of wood are placed at right angles to the first layer. The wood is then covered with a small quantity of Dryco and this is followed by another layer of wood. The paper is ignited and, when the wood is burning, the grate is filled with Dryco.

The same result can be obtained using newspapers only.

A double sheet of newspaper is folded into four, twisted lightly into a large spill, and tied into a single knot. Using knots of paper in place of wood kindling, and following the same procedure as for wood, the Dryco ignites just as readily.

The latest method, however, of lighting a fire is by means of a gas burner fitted in the grate for this special purpose or by a gas poker attached to a position on the wall by means of a flexible tube. In this way any fire, whether it be coal, Dryco or other fuel, can be lighted with the minimum of trouble. Dryco should be stored in a dry place as the presence of moisture impairs its ignitability.

Cost of Dryco.

The cost of producing Dryco is naturally more than that of making ordinary gas coke. In the first place specially selected coals of suitable quality have to be purchased and thoroughly mixed by a blending plant. During carbonization special care is necessary in regulating the temperatures and in fixing the period of carbonization. In maintaining the most suitable conditions the make of gas is rather less than under ordinary circumstances. There is further expense due to the breaking and grading of the fuel.

As the Eccles Street Works have not yet been entirely turned over to the manufacture of Dryco, it has not been possible to arrive definitely at its final cost of production, but from an estimate based on the actual experience so far gained it has been found that the cost per ton of fuel is approximately 7/6 more than the price of gas coke.



“ Dryco ” and Coal of equal weights.

The cost of Dryco delivered in bags is made up as follows :—

Yard price of Gas Coke	..	25/-
Additional cost of Dryco	..	7/6
Cost of bagging and cartage		6/8
		—
Price delivered within 3 miles		39/2

Dryco can therefore be sold at a price below that of the best house coal and, in view of its higher radiating efficiency, its smokeless properties and other advantages, is already in good demand, a demand which will increase as its advantages become known.

In most homes the cost of fuel is an important item, but the householder generally speaking has only a hazy idea of the relative costs of the various fuels. It is not easy for him to obtain definite information as there are several variable factors.

In Table IV. an attempt is made to give relative costs in the form of the amount of heat obtainable for 1d. assuming certain prices and efficiencies of use.

The comparison is really unfair to the solid fuels, as their radiation efficiencies only have been taken. In the case of gas, the efficiency of 75% is made up of 50% radiation and 25% convection, the other 25% entering the flue and performing the useful function of ventilating the room.

Electricity is created with 100% efficiency, which can only be obtained in a sealed room without any ventilation whatever, Such a room would of course be unhealthy to live in.

TABLE IV.

Description of Fuel	Price	Efficiency of Use	Effective Heat Units for 1d.
Dryco ..	39/2 per ton ..	30%	18,387
Coal ..	45/- per ton ..	20%	10,785
Gas | ..	7.4d. per therm	75%	9,121
Electricity	1d. per unit ..	100%	3,412

Conclusion.

It has been clearly demonstrated that a good smokeless solid fuel can be produced on a working scale by High Temperature Carbonization at reasonable cost, without interfering unduly with the Gas Making Process as usually carried on by most Gas Undertakings. If proper care is taken in manufacture, the fuel produced will burn well in any ordinary open grate and will fully satisfy the need for a good smokeless fuel. In conclusion the author wishes to express his thanks to members of the Liverpool Gas Company’s Chemical Staff, Messrs. H. P. Lupton, H. H. Thomas, and J. J. Brown for the assistance they have given in the preparation of this paper and to Mr. H. Nicoll for the help he has rendered with the illustrations. He has also to acknowledge his indebtedness to the Directors of the Company for allowing him to present this paper.

**National
Smoke Abatement Society**

PROCEEDINGS

of the

Newcastle

Conference

1932

**Price :
One Shilling**

**23 KING STREET
MANCHESTER**

PROCEEDINGS
of the
Fourth Annual Conference
of the
NATIONAL SMOKE
ABATEMENT SOCIETY
HELD AT
Newcastle upon Tyne
September 23rd, 24th and 25th
1932



CONTENTS :

Presidential Address <i>by</i> Dr. H. A. Des Vœux	3
The Domestic Smoke Problem: The Possibilities of Coke Oven Fuel <i>by</i> R. A. Mott, M.SC., F.I.C.... ..	8
The Psychological Effects of Smoke <i>by</i> Alderman David Adams, J.P.	34
The Human Element: A Factor in Smoke Abatement <i>by</i> A. E. Crossley... ..	47

PRESIDENTIAL ADDRESS

By H. A. DES VOEUX, M.D.

Delivered at a Reception to the Society by the Lord Mayor and Corporation of Newcastle upon Tyne, at the Laing Art Gallery, on September 23rd, 1932.

No two places in England could show with greater markedness the effect of trade upon localities than the Borough of Lymington upon whose confines I live, and the City and County of Newcastle upon Tyne where we are now gathered. Probably few here have any personal acquaintance with Lymington, and it may surprise them to know that it was an important trading place long before Newcastle was heard of. It was one of the ports with which the Phoenicians traded, possibly as early as 700 B.C., and certainly was important in the centuries that followed, for it was surrounded by an earthen rampart by continental Celts in 200 B.C. In the beginning of the Christian era a Roman camp was formed on the site of the town, and a battle was fought by them against the Britons on a site near my house which is known as "Latchmoor," meaning "the field of carcasses."

Later on battles were fought between the Saxons and the Britons, and the former, in their usual destructive fashion, burned the town in 519 A.D. In the time of Henry I. it became a very important place. It belonged to the family of de Redvers and was made a Borough in 1150. Its importance was due to it being close to its Salterns, in which salt was extracted from the sea, and for which £60,000 a year was paid in duties to the Crown. Later on it was on several occasions attacked by the French and twice burned down. Then and after it became a very important shipbuilding centre, when our men-of-war were built of oak, easily obtained from the New Forest. Through these two industries—salt and shipbuilding—and its harbour, since silted up, it was a rich centre of commerce and shipping.

When iron was required for ships and coal became necessary for manufacturing purposes, and salt was discovered in Cheshire, the town languished, and for the last century it has been a quiet residential centre; a very typical instance of an English country town—clean and small, and only a shopping centre for the neighbourhood.

Comparing this small town with Newcastle is almost like the comparison of the small pleasure yachts—which are still built in Lymington—with the enormous battleships, the products of Newcastle; and it might almost be said that the

PRESIDENTIAL ADDRESS.

greatness of the latter depends upon the collapse of the former—the change-over from wood to iron and coal.

I know that my history is not quite correct, but it serves my purpose. The two are typical of their kind; one still medieval country town, the other the large and usually flourishing manufacturing and shipping centre with all its advantages and disadvantages.

The principal disadvantage of these modern cities, as we of this Society see it, is due to the consumption of coal and the consequent dirt due to the emission of smoke. It is to make the amenities of places like this equal those of my Lymington that our Society exists, and Conferences such as we are opening to-day are for the purpose of drawing local attention to the evils of smoke, physically and morally; a duty which is urgently necessary in such great cities as Newcastle, but unnecessary in a county town like Lymington. I think it might be invidious of me, as your grateful guest, to point out why it is necessary, for your Medical Officer of Health has no doubt done so on many occasions, and in such terms as I should not dare to employ, but which, without apology, I may be allowed to say are none too strong.

Your progressive Corporation are represented on the Conference of Local Authorities which studies atmospheric pollution, and are well aware of the terrible cloud of smoke from which you suffer, and are, I am sure, doing all they can to diminish this foulness from your atmosphere.

The business of my Society is to impress on every citizen throughout the Kingdom that the time has come when by determination and concentration of purpose this curse of modern life can be steadily diminished until its complete elimination becomes only a matter of time. This can be accomplished with injury to none and with untold benefit to all.

There would be improvement in health and physique; disappearance, or at any rate greater frequency of such diseases as bronchitis and heart disease; great saving in the cost of living through the removal of the principal cause of dirt, which is an expensive item in the town dweller's household bills; saving in the destruction of all structures of stone and iron, of which the principal cause is the tar and sulphuric acid in coal; increase in the amount of sunshine with consequent removal of the murky gloom which is so constant in our big cities.

It would be easy to give a complete list of the disadvantages of such an atmosphere as you have here and the advantages of the one we enjoy in Lymington—all I want to

impress upon you is that it is or shortly will be possible, if you make up your minds that you will have it, not to rob Lymington of its clean air as you did its trade, but to vie with it in its purity.

There are one or two things special to this year to which I wish to refer, and one is to the effect of the smoke of one locality upon another. It has been shown that the smoke from a centre like London can be carried under suitable conditions at least sixty miles, and I have smelt it myself thirty miles to the south-west of London, and therefore it seems to us absurd that the smoke should be dealt with as a purely local matter. The air even on the stillest of days is always moving, maybe only about two miles an hour, but with it the smoke travels, and one of the great troubles which we have had to deal with in London has been that there are about 130 authorities dealing with pollution of the air; some do nothing, others are lax, and some are constantly at work upon it. But the smoke of one district affects its neighbours almost as much as itself, and in such cases the good suffer for the negligence of the bad. The only method by which this difficulty can be overcome is by the formation of Regional Statutory Committees comprised of all the authorities concerned, and possessing the powers of these authorities. This leads to uniformity of practice over a large area, and prevents injustice as between one locality and another; and in the one case in which this has been done—the Sheffield, Rotherham, and District Smoke Abatement Committee—I can read in their report that no difficulties have been encountered, and that it has met with the success which my Society has always prophesied.

I feel sure that if other districts would follow this example and map out what they consider a “smoke area” and invite other neighbouring authorities to join in forming such a statutory committee, benefit would follow, and that the smarting feeling of injustice in the minds of factory owners would disappear.

In the case of the Sheffield and Rotherham Committee, which already is formed of representatives of six authorities, and hopes shortly to induce another to join, there is inter-communication between this statutory committee and a voluntary manufacturers’ committee; a sign of the times at which the National Smoke Abatement Society rejoices.

To those who fear that a Statutory Committee would lead to increased persecution from “Inspectors” I would point out that only four inspectors are employed, who manage to keep under observation 6386 chimneys, and that only nine prosecu-

PRESIDENTIAL ADDRESS.

tions took place in the year ending March, 1932. The total cost to the combined authorities was £1,781—not a large sum for such an important and large manufacturing district. Of this total £200 was given for research. Why do not other districts follow the wise example of Sheffield and Rotherham?

Another subject which my Society wishes to bring to the fore is the question of the danger of carbon monoxide from the exhausts of motor cars. It is not generally known that an ordinary car running at about thirty miles an hour emits one cubic foot of this deadly gas per minute. Every motor car owner knows how unsafe it is to allow the engine of a car to be running with the door of a garage closed; but what is unknown is what danger there is in large garages where many cars are started within a short time of one another, and I should be grateful if some M.O.H. would cause systematic examinations to be made of the blood of those whose occupation confines them to garages.

Another question which urgently needs answering is: is there such a thing as chronic carbon monoxide poisoning? What is the effect on still days of this gas on occupants of cars when in a long block of traffic? So far, none has been traced, but I have a strong suspicion that cases such as the following are not so uncommon as is generally supposed.

This is the precis of a report of a gentleman of my acquaintance. He was driving on a cold day in a closed car with all windows but one closed. In a narrow road the car overtook a lorry which was emitting "excessive exhaust fumes," and owing to the narrowness of the road the car was unable to pass. The fumes from the lorry blew into the car, which was slowed down to avoid them as they were so objectionable. Later they were able to pass, when the gentleman was "seized with extreme giddiness," and then vomited; he then collapsed and became nearly unconscious, and recollected little of what happened until he found himself in bed in hospital.

He was considered so ill that his wife was telephoned for. His blood was examined later, and disclosed the usual signs of carbon monoxide poisoning. His chauffeur suffered the same evening from violent headache, and it was this only that threw suspicion on carbon monoxide; otherwise the gentleman's attack would have been considered an ordinary attack of syncope or faintness, for which he was actually treated. Even doctors may have luck on their side.

I hope that in these remarks I shall have convinced you that my Society is a serious one, that it has no axe of its own to grind, and that its only object is to improve the condition

PRESIDENTIAL ADDRESS.

of the atmosphere of towns, and to restore to those who have to live in them the original purity of the one element without which none of us can escape annihilation if we are deprived of it for three minutes. Remember you can be deprived of water three days, of food three weeks, and still survive; but you breathe into your system your draught of air sixteen times every minute, and although you spend large sums of money in securing the purity of your food and water, you breathe your polluted air with little or no complaint. And yet you will be offended if I call you uncivilized, and therefore I shall not venture to do so; but will content myself by telling you that it was a Chinaman who said it to me!

THE DOMESTIC SMOKE PROBLEM: THE POSSIBILITIES OF COKE OVEN FUEL.

By R. A. MOTT, M.Sc., F.I.C.

DR. J. T. DUNN, J.P., F.I.C., who presided, in introducing the speaker, said that it was difficult to say anything new on the subject of smoke. He mentioned briefly the cost and losses due to smoke, the effect upon vegetation, and the effect the stoppage of sunshine has upon health, both physical and mental. A year or two ago Mr. Orme made a comparison for the three years 1923-26, of the records at Cockle Park, the Northumberland County Experimental Farm, near Morpeth, and at Armstrong College, and showed that in the summer time Newcastle only received half, and over the whole year, only two-thirds of the sunshine received at Cockle Park. With a clear sky and doubled summer sun, how much less need there would be for the sun-ray clinics—and further, how much more bright and cheerful we should all be.

His partner, Mr. Bloxam, and he had found that the soot from their chimneys, and therefore the dust that accumulates in their houses and needs continually to be removed, contained quite sensible amounts of compounds of lead and copper, and in some cases of zinc and arsenic. Chimney soot contained 350, dust from the bookshelves in the office of the laboratory in Dean Street contained 500, and that from the portico over the front door contained 900 parts of lead per million; whilst the suspended matter collected from the atmosphere in the City Road soot gauge contained 3,200 parts of lead, and 440 parts of copper, per million. These were relatively small amounts, but to breathe continuously air containing them could not be good for health.

The industrial smoke problem, though not completely solved, had been rendered much less urgent, but the domestic smoke problem had still to be tackled, and this in most places was the more serious. It was with this that Mr. Mott was going to deal. He would no doubt indicate, and therefore the speaker need not, the many directions in which this problem could be attacked, but he would deal in detail, if not entirely, with one of them—the use of coke. As a worker in the Sheffield University Department of Fuel Technology, and in the Midland Coke Research Committee, Mr. Mott devoted his

time entirely to fuel problems, and very largely to coke. He was one of their leading investigators into the production, and the properties and uses, of coke, and when they listened to him they would hear the authoritative voice of an expert. He had pleasure in asking Mr. Mott to speak.

Mr. R. A. MOTT then read his paper:

The smoke pall which overhangs most of our large cities can be attributed for the greater part to "domestic" smoke. Indeed some authorities assess the proportion to be ascribed to "domestic" chimneys as high as two-thirds and it is clear that no marked progress towards the abolition of the smoke nuisance will be possible until means are available to prevent the production of smoke from house chimneys. Progress in smoke abatement has been most marked so far as industrial smoke is concerned, partly because industrial smoke is produced from fewer units and partly because the production of industrial smoke can usually be shown to lead to a loss of efficiency, which it is in the interests of the smoke producer to remedy. Domestic smoke, on the other hand, is produced from an enormous number of small units, of the order of 8 million, which can only be influenced by a radical change in the methods of using fuel. The fuel at present used is almost entirely coal, for purposes of heating, cooking, hot-water production, and numerous other important duties such as clothes drying. The purpose of this paper is to examine the duties which coal fires have at present to perform and to see how these duties could be performed satisfactorily by a smokeless fuel produced in coke ovens. It is no part of the writer's province to discuss the evil effect of domestic smoke. This is well known to this Society and it is sufficient to say that the abolition of domestic smoke would be an important step towards improving the health of mankind and the amenities of living.

It would be well to examine the various duties which coal has to perform in typical houses and to give some information on the production of smokeless fuel in coke ovens before discussing how smokeless coke-oven fuel can be adopted to meet the various requirements.

The Duties of Coal Fires.

It is estimated that about 40,000,000 tons of coal are used annually for domestic (house) purposes. With 8,000,000 houses, this is roughly equivalent to the use of an average of

COKE OVEN FUEL.

2-cwt. of coal per week throughout the year in each household. Actually there is a seasonal variation in the demand for coal, more being required in the winter than in the summer. It is convenient to divide houses into different types according to the different duties which domestic fuel has to perform, namely, the small house in which one room is usually used as a "living room;" the medium-sized house in which a dining and sitting room as well as a kitchen are used regularly; and large houses in which a number of additional rooms are used occasionally and numerous bedrooms are available.

In the small house the amount of money available for house heating, cooking, water-heating and clothes-drying is strictly limited, and the most economical method of meeting these requirements has to be adopted irrespective of the thermal efficiency with which each duty is performed. The coal fire is still the commonest fuel-using unit for performing these duties, but it is now doubtful whether it is the cheapest. A coal fire fitted with a back boiler, and connected to an oven, can be used to warm the room where it is installed, can meet most of the requirements of cooking, can provide hot water for washing dishes, and, with extra stoking, hot water for baths. With its intense radiation, it dries clothes quickly and provides (when not used for clothes drying) a bright cheerful centre for the family circle. Moreover it performs an important function in ventilating a room, the air of a room being changed several times per hour. It is because the coal fire can be adapted for so many uses that it has become so popular. The thermal efficiency with which these duties are carried out is not high, as may be seen from figures obtained by Barker¹ as follows:—

Ordinary Brick-Set Kitchen Ranges.

Heat communicated to food	...	...	...	3 per cent.
Heat communicated to hot water supply...	7	"	"	
Absorbed in the brickwork	...	...	...	35 " "
Loss in the air of the kitchen	...	...	...	30 " "
Lost in the flue gases	...	...	...	25 " "
				<hr/>
				100 " "
				<hr/>

A boiler designer wishing to obtain a high thermal efficiency for the use of his coal would see that the combustion of coal were complete before he allowed the flames to come in contact with cold surfaces, and the back boiler of an ordinary

¹Tests on Ranges and Cooking Appliances. Fuel Research Board Special Report No. 4.

range is thermally inefficient because this is not allowed, since the space permissible for a fire-place, and the nature of coal, preclude this. Coal may be considered to yield on heating 30 per cent. of "volatile matter" and 70 per cent. of coke. The "volatile matter" consists of one-half gas, one-third tar, and one-sixth water. The gas, because of the restricted space of a fire-place and the drastic dilution with air, is only partially burnt; the tar is still less efficiently consumed and is the cause of most of the smoke produced, whilst the water has no heating value.

The entirely-closed stoves, commonly used on the continent for domestic heating, cannot meet all the requirements of the small householder in this country, although they are more thermally efficient because the products of combustion are less drastically diluted with air and combustion is more nearly completed. In the damp atmosphere of this country, which, with low temperatures, has such a chilling effect on the skin, the use of direct radiation such as is obtained from a bright open fire, or a modern gas fire, is comfortable. In the opinion of the writer, the sentimental attachment to an open fire is, to a large extent, a psychological effect associating comfortable warmth after exposure to a chill damp atmosphere with the chief characteristic of the open fire, namely, its cheery brightness; for there is no demand for a bright radiating surface in summer, even when the sun does not shine, provided that the temperature is high enough. If, therefore, a sufficiently high temperature can be maintained in a house, the same need for a bright radiating surface does not arise. It is not, however, the intention of the writer to argue that an open fire with its intense radiation is not desirable, for it has been shown, for example by Sir Leonard Hill, that short-wave radiation obtained from a very hot surface such as one of the newer types of gas fire, has a stimulating effect on the skin. The lower temperature of an electric radiator has not the same effect, but radiation from a bright coal or coke fire may be expected to have a similar effect. It may therefore be concluded that a fire which can be seen and can radiate heat directly into a room is desirable.

The cooking duty which a coal fire is called upon to perform is the least satisfactorily carried out of all the duties. For oven heating, particular care has to be paid to the cleanliness of the fire and it is usual for the housewife to use specially-selected pieces of coal to ensure that the oven gets hot. A long flame is required by the coal-fired oven of present design, and it is certain that the long flames will be very smoky. Extended cooking operations using the oven require

COKE OVEN FUEL.

a faster rate of stoking and the radiation of the open fire makes the room uncomfortably warm and heat is wasted. In boiling operations the irregular temperature of the top of a fire, which may vary from a black surface to a red one, is a disadvantage. Another unpleasant feature is the grimy deposit of tar and soot which covers the pans. The disadvantages of a coal-fired oven are indeed recognised by the housewife as is shown by the rapid adoption of gas cookers in recent years.

The duty of clothes-drying, which an English home fire is frequently called upon to carry out, is done perhaps more efficiently than any other operation. The open coal fire is unrestricted at the front and the top and provides a large radiating surface which is extremely satisfactory for rapid drying.

In a sitting-room grate where coal has only to perform the function of heating a room, less smoke is produced than in the kitchen, for on a modern well grate the cobbles or cubes usually used offer a large free surface for the ignition of fresh charges of coal and, there being little need to disturb a fire of low ash British coal by poking, the combustion can be completed fairly satisfactorily, although the radiating efficiency is only 20 to 25 per cent.

Coke Ovens.

It is now possible to examine how coke-oven fuel can meet any or all of these requirements. Few people are aware of the operations carried out at a coke-oven plant for these are concentrated in out-of-way colliery areas. About 12,000,000 tons of oven coke are produced annually, about one-third of this in Durham, one-third in South and West Yorkshire, one-tenth in South Wales and Monmouthshire, and one-twentieth each in North Derbyshire, North Staffordshire, Cumberland, Lancashire and Scotland. Twenty years ago practically no oven coke was used for domestic purposes, about 95 per cent. being used at blast furnaces and foundries and the rest exported. In recent years, the amount used at blast furnaces and foundries has fallen to about 70 per cent., 13 per cent. is exported and about 17 per cent. (2 million tons) used for domestic purposes.

To make oven coke, coking coal must be used. This is usually crushed to less than $\frac{1}{4}$ -in. size and is loaded into an oven 33 to 40 feet long, 8 to 15 feet high, and 14 to 22-in. wide. a charge of 10 to 16 tons being used for each oven. The coal may be charged from a car carrying a number of hoppers from which the coal enters the oven through 4 charging holes on the top. Alternatively, the coal may be compressed into

a cake and passed into the oven through one side door. After charging an oven, the doors at each end are sealed and the coal is heated from flues on each long side of the oven. After a period of 12 to 36 hours, depending on the width and other details of design of the oven, the whole of the volatile matter has been driven off and the coke is discharged by a ram operating through one of the end doors, the coke being discharged on to an inclined bench and quenched. Subsequently the coke may be screened into different sizes, additional supplies of nut sizes being obtainable by "cracking" large coke in a suitable crusher and rescreening.

The Use of Oven Coke—General.

Oven coke as normally made is hard and massive and contains only about 1 per cent. of volatile matter, none of which is tar. The absence of volatile matter and the high temperature to which it is heated in the oven, say 900°C , makes it more difficult to ignite than coal, but it burns, without producing any smoke, with a clear blue flame. The difficulty of ignition is due to the fact that it reacts less readily with air than does coal, and oven coke is spoken of as being of "low reactivity." Because of its low reactivity it will not usually burn in a well grate and a special design of grate, which ensures a good draught, has to be adopted to burn coke in an open fire. The coke fire is made to supply the draught itself by using a relatively deep bed and, in some cases, directing the products of combustion into a flue to which excess air cannot penetrate, the ventilating current of excess air being directed under a canopy in a separate flue to the common chimney. The isolation of most of the products of combustion into a separate flue produces a good enough draught and no difficulty is then experienced in maintaining combustion.

In a closed stove, which is simply a fire pot with a closed top and with front doors capable of being closed so that all the air enters below the fire, oven coke burns with ease and no difficulty exists either in lighting or in the maintenance of combustion if the correct size of coke is used. In a "closed stove" of English design, the front doors may be opened when the bed of coke has become hot and an open fire is obtained. The fire consists of a bed of coke 8-in. or more deep at a bright red heat with an extremely cheerful appearance. The "closed stove" may be fitted with a saddle water boiler on end, that is, filling the two sides and back of the fire pot and connected with the storage cylinder and the cold water supply. The supply of domestic hot water is a function carried out very efficiently by a "coke boiler" for the water is heated by

COKE OVEN FUEL.

radiation from the incandescent coke and there is no cooling of flames causing incomplete combustion as in a coal-fired boiler. There is no smoke produced.

The Use of Oven Coke in a Small House.

The water heating thermal efficiency of a small coke boiler has been found to be 40 to 50 per cent., that is half the heat of the fuel may be obtained as hot water. The efficiency is therefore at least twice as high as the best type of back boiler of a coal-fired kitchen range.

The coke boiler may be adapted for using the waste heat for cooking purposes. In one adaptation an oven surmounts the small coke boiler which is about 2-ft. 6-in. high, the waste gases from the boiler being passed through a series of flues round the oven which has a flue pipe fitted to the top. The maximum temperature required in an oven, for example for roasting, is only 500°F. and by suitable insulation, there should be no difficulty in maintaining this temperature, and, by the admission of air to dilute the flue gases, a lower temperature can be obtained.

Another variety of coke-fired oven has the oven alongside the boiler giving an extended hot plate area at one level. Dr. Fishenden¹ records that "for all round efficiency, no other ranges on the market are to be compared with these of independent boiler origin, especially where the demand for hot water is high Where the oven is at the side of the fire, the adequate provision of boiling rings renders the range capable of meeting the entire cooking demands of an average household."

The development of this type of appliance should go far to meet all the requirements of a small household at present met by a coal-fired range. With a suitable size of coke, an open fire can be maintained, and therefore the appliance should supply hot water, perform all the cooking operations, and give a cheerful red fire. No variety of closed stove, however, gives the same rapid clothes-drying service as an open, unenclosed fire for the radiating surface is restricted and the radiation is confined to a small area at a low level, in front of the fire. This disadvantage, may, however, be overcome by the use of a clothes-drying rack suspended from the ceiling, and a longer time allowed for the drying operation, for example, overnight. Rapid clothes drying is possible over a restricted area immediately in front of the fire, and requires frequent changing of the position of the clothes. Some makers of closed coke stoves

¹House Heating. London. 1925. p. 142.

arrange for the top of the boiler to be raised and so allow radiation from the fire at higher levels. On the whole, the disadvantages associated with the enclosing of the top of the stove are outweighed by the advantages in increased thermal efficiency which allows a real economy in use. The open fire cannot be efficient for water heating and cooking operations so long as unrestricted dilution of the products of combustion with excess air is allowed, and this can only be controlled by enclosure of the top. The design of these "closed" stoves is worthy of serious attention to make them the most suitable for the small house. The balancing of the size of the boiler and the insulation of the oven and the amount of heat radiated from the open fire to meet the requirements of the small house should make this appliance an economical, pleasing and reliable unit.

Use of Oven Coke in Medium and Large Houses.

In larger houses, economy is not always so important as convenience, and there can be no doubt, in the writer's opinion, that cooking operations can be performed most satisfactorily by a gas cooker. The balancing of the different requirements of hot water production, cooking and open fire radiation is admittedly difficult, and there is no doubt that each operation is more satisfactorily carried out if independent units and controls are used. The most satisfactory method of raising hot water is undoubtedly to use an independent coke boiler, and this can be conveniently placed alongside a gas cooker. This arrangement would not preclude the fitting of an oven to the coke boiler and using this for auxiliary use, a feature which would often obviate the use of the gas cooker for small cooking operations. The modern gas cooker is a very much better product than that available ten years ago and is thermally more efficient and therefore uses less gas for a given service. The cooker is better insulated than formerly, a most important factor in reducing the amount of gas required, whilst the circulation of gases, to leave at a bottom flue instead of at the top gives up much more of the heat of the burnt gases than formerly. When fitted with a thermostatic control to maintain a required temperature by the automatic control of the gas supply, the modern gas cooker is a very serviceable product. By the use of enamel finishes its appearance is much improved and is more easily kept clean. The use of an independent gas cooker—using a fuel which in many towns near the coking-coal fields is a "coke-oven fuel" (coke-oven gas)—allows a required oven temperature to be quickly attained and

COKE OVEN FUEL.

automatically maintained. Boiling operations are quickly carried out with gas rings.

In a medium-sized house the operations formerly carried out by a kitchen range can be more conveniently and efficiently carried out with a combination of a gas cooker and an independent coke boiler, both being under exact control and each rendering a service independent of the other. The conversion of a kitchen range to this arrangement may be carried out very cheaply and is the method adopted in the writer's house. The kitchen range was removed, the chimney breast raised 1 foot, giving an opening 5-ft. 6-in. high, 4-ft. wide, and 1-ft. 6-in. deep. This recess was covered with white tiling with a facing of white tiles on the two sides and at the top, an operation which cost about £12. In the recess was fixed a Mainservor gas cooker with thermostatic control and a Sentry No. A domestic coke boiler which was connected to the existing hot-water cylinder. Both the appliances were finished in mottled enamel so that the whole setting was much more pleasing in appearance and more easily kept clean, than the black range it replaced.

The coke boiler is charged with oven coke nuts of $\frac{3}{4}$ to $1\frac{1}{4}$ -in. or 1 to $1\frac{1}{2}$ -in. size and gives a bright cheery open fire and supplies hot water for all domestic requirements with great ease. The size of oven coke used is a most important factor; with oven coke of 1 to 2-in. size, the fire was not regularly bright and was liable to go out several times a day. With coke of $\frac{1}{2}$ to $\frac{3}{4}$ -in. size the boiler could be kept in all night, but since it can be so easily lighted by a gas burner, it is allowed to go out each night. Oven coke nuts is a most satisfactory fuel to use for a small coke boiler, for it is denser than gas coke (a bucket of oven coke nuts holding 13-lb. compared with only 11-lb. for gas coke) and burns more slowly, that is, it is less reactive. With gas coke it was more difficult to control the operations of the boiler with the front doors of the boiler open, the gas coke burning more rapidly and the safety valve blowing frequently. With the right size of oven coke, the fuel can be burnt sufficiently slowly to maintain a bright open fire and give sufficient hot water for domestic requirements, whilst, with a big demand for hot water, the front doors can be closed and the damper opened to increase the rate of combustion and production of hot water. The amount of coke used per day in winter is about 25-lb. keeping a bright fire for at least 12 hours, a rate of 2-lb per hour compared with 3-lb. of coal per hour used in a kitchen range.

The fire is lighted by filling the pot completely with coke, opening the damper fully and the ash pit opening about 2-in.

and putting a gas burner between the bars for about 20 minutes.¹ The burner is then removed, the front doors closed and a fire bright to the top is available in a further 40 minutes. The front doors are then opened and remain so throughout the day, except in special circumstances. No clinker is formed and the ash is poked out at intervals during the day, the ash pan being emptied once or twice daily. In the summer the front doors of the boiler are kept closed, since no heating of the kitchen is required, and a plentiful supply of hot water is produced without raising the temperature of the kitchen uncomfortably. The top of the boiler is used as a hot plate and, by removing the top charging cover, pans may be boiled rapidly without covering them with soot or tar. Toasting can be efficiently carried out in front of the fire. With a combination of gas cooker and coke boiler, all cooking operations are carried out without discolouring the outside of the pans and kettles, and the housewife can discard her heavy cast iron pans and kettles and use aluminium or light enamel which can be kept as clean outside as inside.

The boiler is fitted with two draw-off cocks and any deposit in the boiler can be run off at intervals. This is indeed an important feature of the independent boiler when the water is hard or is not perfectly clean, as is the case of the author's house served by a main which has only a small service demand and a fine suspension of rust is present in the water. This suspension formerly fouled the back boiler of the kitchen range until it cracked, whilst the hot water was brown when the fire was much used. By running off the brown deposit at intervals the hot water is perfectly clean, however hot it is.

A further use for oven coke in a medium or large house is for central heating. No one who has experienced the comfort of a house which is centrally heated in winter would like to be without an installation. In the writer's house a separate coke-fired boiler in the kitchen supplies heat to a sitting room, dining room, four bedrooms, a hall, and upstairs landing, whilst the heat from the central-heating boiler in the kitchen enables the domestic coke boiler to be operated at a lower rate, and the bathroom is kept warm by the hot water cylinder, always full of hot water. The piping was put in after the house was built, but little difficulty and no serious disadvantage arising in fixing it. With a series of seven radiators and

¹An extra gas nipple may be placed on the gas-supply pipe of the gas cooker to accommodate the "gas poker." The fire can, of course, be lighted with paper and sticks, but, where a gas connection is available, a gas poker is always more convenient whatever the type of fire to be lit.

COKE OVEN FUEL.

the hot water pipes, the whole of the house, except the sitting room and cellars, is maintained at a temperature of about 60°F throughout the day. The sitting room, approximately 20-ft. by 14-ft., is kept at a temperature of 55°F, so that the further heat required may be supplied by an open fire.

The coke boiler is an Ideal Classic No. 3 about 34" high, 15" wide and 16" deep, and has a mottled enamelled jacket. It is placed in a recess in the kitchen alongside the chimney breast which the flue pipe enters at a suitable height. The fire pot has a capacity of $1\frac{1}{4}$ cubic feet, and holds about 40-lb. of coke. The boiler is fitted with a thermostat or temperature regulator which maintains a desired temperature of the hot water leaving the boiler. The thermostat operates a lever fitted to a chair fixed to the door below the fire-bars where the air enters. As the bed of ashes accumulates in the fire the increased resistance reduces the amount of air passing and the water temperature drops. The thermostat then operates and the door is raised until, with the increased amount of air entering and the rate of combustion of the coke increasing, the predetermined hot water temperature is regained. The thermostat operates satisfactorily, although the temperature falls somewhat during the night, as the coke bed falls and a thick ash bed accumulates. The fire is maintained throughout the winter, fresh coke being charged at intervals (two to five times per day according to the weather prevailing, each charge being say 13-lb.), the bed poked to remove ash, and the ash pan emptied once or twice per 24 hours.

The size of coke used in the larger boiler is not so important as in the small boiler, but is still an important factor. Oven coke nuts of $1\frac{1}{2}$ to $2\frac{1}{2}$ -in. or 2 to 3-in. are used, such a size rendering the building up of the coke charge to the top of the pot a simple operation and being less liable to form clinker. When using the same size of coke as in the smaller boiler, namely 1- $1\frac{1}{2}$ -in., clinker is formed at a lower rate of combustion, and this increases the attention required. With coke nuts of 2-3-in. size the ash of the coke is removed as fine powder for low rates of burning but, at the fastest rate, the ash fuses into small particles of clinker, still small enough to riddle through the fire bars. With the 1- $1\frac{1}{2}$ -in. size of the same coke the faster rates of combustion used would give a sheet of clinker which would have to be pulled out through the charging door. The size is therefore important in controlling the ease of operation. It is also desirable that the ash should be heavy. The writer has used two cokes of approximately the same ash content, one of which would give after burning overnight a depth of ash of about 4-in., but the other would give

COKE OVEN FUEL.

a bed of 3-in. With the shallower depth of ash the water temperature does not drop so much.

The coke consumption varies with the outside temperature, the house temperature being maintained fairly constant. The lower the outside temperature the more coke has to be burnt to meet the heat losses through the walls and windows. The whole of the coke fed to the boiler was weighed during the month of January, 1932, and the temperature was noted in each room and outside the house 4 to 6 times during the day. The average result of these operations is that 50-lb. of coke had to be burnt per day to raise the temperature from 43 to 59°F. When the outside temperature was as low as 32°F. the amount of coke burnt per day was about 60-lb., though the temperature of the house would fall to about 56°F., and when the outside temperature was 50°F. the amount of coke burnt per day to maintain a temperature of about 60°F. fell to about 25-lb. per day. With coke at 30s. 0d. per ton the cost is therefore about 9d. per day, but this expenditure saves the use of a fire in the dining room, and reduces considerably the amount required for the open fire in the sitting room. Moreover gas fires in the bedrooms were not used much except on chilly mornings when, the temperature falling to about 50°F. (the windows being open), the fire would be used for a short period.

The heat required to heat the house has been calculated to be approximately 20,000 B.Th.U. per hour, and with the average use of 2.08-lb. of coke per hour, approximately four-fifths of the heating value of the coke is usefully employed, a very high efficiency for a domestic heat-using appliance. The installation was designed to raise the temperature of the dining room, hall, landing, and one bedroom (used as a children's playroom) from 40 to 60°F., the rest of the house being warmed from 40 to 55°F. The average winter temperature in England is about 40°F., so that by designing the installation to meet average conditions the initial cost is kept lower.

Records of fuel consumption in the writer's house in recent years are as follows:—

1927-1928	...	...	5 tons 8 cwt. coal	
1928-1929	...	...	6 tons 4 cwt. coal	
1929-1930	...	...	7 tons 9 cwt. coal	
1930-1931	...	...	6 tons 5 cwt. coal	
1931-1932	...	...	1 ton 6 cwt. coal	
			5 tons 10 cwt. oven coke }	7 tons 10 cwt.
			14 cwt. semi-coke }	

Records of gas consumption do not yet show any reduction, since in the winter months a gas fire in one bedroom was

COKE OVEN FUEL.

generally used during the nursing of a child, but there should be a reduction in the amount used under normal conditions. Increased use was, however, made of an electric radiator in the dining room at breakfast time until a change could be effected in the hot water flow to the circuit feeding the ground floor, but the increase only amounted to about 50 units in one quarter. The heating system was only in use 5 months compared with the 7 months it will usually be used, but it is clear that but little extra fuel will be used compared with the old conditions.

Calculating from the period each fuel-using appliance was used to a normal year the expected fuel consumption would be:—

Coke for small coke boiler (domestic hot water, kitchen heating and hot plate use) for 12 months (12 to 15 hours per day)	3 tons 5 cwt.
Coke for large coke boiler (central heating) for 7 months (24 hours per day)	3 tons 5 cwt.
Fuel for sitting room open fire (small) for 8 months	1 ton 0 cwt.
Total	7 tons 10 cwt.

Since oven coke costs at least 2s. 0d. a ton less than house coal it is to be expected that no greater running cost will result under the new conditions, and the expenditure will be limited to the initial cost. Under the new conditions of using fuel, however, a much greater standard of comfort is obtained.

The benefit of centrally heating a medium-sized house may be summed up as follows: There is less restriction in moving about a house and in occupying a greater proportion of each room; there is no discomfort in entering cold bedrooms, and the dining table and chairs need not be brought close to a fire-place, and fires in rooms partially centrally-heated need not be lit so early. Cold draughts are almost abolished for air entering rooms from a hall is as warm as the air in the rooms. The comfort of a centrally-heated house has to be experienced to be appreciated to the full.

The cost of installation in a medium-sized house is about £50 to £75. Coke-fired boilers are entirely smokeless and a centrally-heated house with a separate coke boiler for domestic hot water and a small coal fire in one room produces very little smoke. Indeed, as will be shown later, it can be made entirely smokeless. It is an advantage, in the writer's opinion, to have separate units for central heating and domestic hot-water production. It is possible to use only one boiler, but this would have to be maintained in use all the year round to produce domestic hot water, whilst, with separate boilers, the

central-heating installation can be out of action for at least 5 months of the year. Moreover, with a single boiler, a double hot-water cylinder has to be used, the inner cylinder being for domestic hot water which heats the water in the outside cylinder for circulation in the radiator system. With severe demands on domestic hot water the central-heating system is starved and excessive hot-water supplies may be produced when a higher temperature in the central-heating system is required. The cost of the installation of the two systems is about the same, so that the advantage remains with the separate installations.

In large houses with long corridors central heating is really indispensable and the system follows the same lines as in a small house, except that the coke boiler is usually placed in a cellar or outhouse close to the coke store.

Coke Fires.

In recent years considerable attention has been paid to the design of fire grates to burn coke in an open fire for room heating. High temperature coke (oven and gas coke) being less reactive than coal or low temperature coke, it cannot be burnt successfully in a well grate. To conserve the heat of the fire it should be surrounded by insulating firebrick at the back and sides. To make the utmost use of convection currents to carry heat from one part of the fire to the other, the fire must be fairly deep from top to bottom, so that heat from the bottom of the fire heats up the coke above and enables it to be easily ignited, instead of having a fire which is deep from front to back (as in a well grate) a coke grate is narrow from front to back. This arrangement requires the use of front bars to support the coke bed. The firebars below a fire may be spaced only $\frac{3}{8}$ " apart for a good coal, but a wider spacing, say $\frac{3}{4}$ ", is desirable for coke to ensure that a plentiful air supply is distributed uniformly to the whole of the bottom of the coke bed. Another device fitted to some coke grates is a shaker operated by the foot to remove ashes at intervals, so that the air supply to the bottom is not unduly restricted. Alternatively, a portion of the front bars may be fairly steeply inclined, so that the coke on settling down the bars has the outer layer of ash detached and the ash falls through the bars. Some coke grates are fitted with a double flue arranged with a damper to control the back flue and using the ordinary canopy to control the front flue. On lighting the fire, the canopy is closed and the back-flue damper opened. This prevents drastic dilution of the products of combustion, which are discharged at a high temperature into the back flue creating a strong

COKE OVEN FUEL.

draught which enables a bright fire to be attained quickly. A back-flue damper is then partly or fully closed and the canopy opened. On refueling, the back-flue damper is again opened for a short time. The provision of a back-flue allows the use of a small fire which will pick up rapidly. Some of the outstanding coke grates may be briefly described as follows:—

The Kaye Grate. The Kaye Grate (C. H. Kempton & Co., Ltd., 72, Bennerley Road, Wandsworth Common, S.W.11), has three horizontal grate bars at the front to enable a bed of coke about 6-in. deep to be built up. The bottom firebars are partly horizontal and partly inclined upwards towards the back, the slope of the inclined portion being continued by a fireclay slab to reach the back. Combustion being mainly at the front of the fire, the partly-sloping base of the fire helps to bring fresh coke to the front. The firebars have wide spaces and are attached to a rocking bar which can be used to discharge ash into the pan. The fire is lighted by means of a burner fitted as a standard with the grate, air being admitted under the fire for this purpose. The writer has seen a Kaye grate burning “unreactive” Durham foundry coke nuts with ease giving a brilliantly red glowing fire of the most cheerful appearance imaginable. Those who admire the cheerful coal fire will find that a coke fire in a suitable grate is still more cheerful with bright blue flames burning above.

The Peveril Grate. (Messrs. R. Russell & Sons Ltd., Peel Foundry, Derby). The Peveril grate is a well-grate fitted with a special “coke valve” connected with a flue behind the normal fire back. By closing the canopy and opening the coke valve, a strong draught is produced and the coke fire is lighted by a fitted gas burner. When the fire has burnt through the coke valve is partly closed and the canopy opened. The fire will recover on refueling in a very short time, even if very low at the time of recharging.

The Waverley grate, made by the same firm, is similar to the Peveril, but is a cheaper production.

The Santore Grate. (Messrs. Newton, Chambers & Co., Ltd., Moorhead, Sheffield). The Santore grate has steeply inclined front firebars and a second flue behind the fire back, controlled by a damper. With the canopy closed and the back-flue damper open, air travels down through the fire and the products of combustion pass up the back flue. When the fire has burnt through the back flue damper is partly closed and the canopy opened. The coke slides down the inclined grate bars discharging its ash.

The Eagle Grate. (Messrs. John Wright & Co., Essex Works, Birmingham). The Eagle grate has inclined firebars with front bars to enable a deep bed of coke to be built up, and is lighted by a gas burner. Like all coke grates it has firebrick surrounds at the back and sides, but these are kept particularly hot by the admission of air through spaces between the surrounds and the firebars, this being an important factor in maintaining combustion. The performance of this grate in practice is very good.

The Metro Grate. (Messrs. Sidney Flavel & Co. Ltd., Leamington). The Metro grate has (1) bottom grate bars which are inclined from the front to the back of the grate at an angle of 30° to the horizontal and are widely spaced, (2) front grate bars to build up the fire, (3) a firebrick surround, and is lighted by gas. The Metro grate is supplied in a large variety of models, with complete installations and adaptations for existing grates, the cheapest used being only £1 2s. 0d. The Metro basket grate used for coke is a particularly pleasing production.

Although a deep fuel bed is used with coke fires, the fuel consumption is not high, being 2 to $2\frac{1}{2}$ -lb. per hour. The deep fuel bed has the advantage that, on refueling, a bright layer of fire is still available for radiating heat. The radiant efficiency of coke fires is much higher than for any other solid fuel fire. Thus, Milner Dyde and Hodsman (J.S.C.I., 1931, 50, 113T) have shown that "high-temperature" coke will radiate 33 per cent of its heating value into a room, compared with 30 per cent. for "low-temperature" coke and only 25 per cent. for coal. By making tests when good fires have been obtained, radiant efficiencies of 40 per cent. were obtained for high temperature coke, but a coal fire radiated little more than in the normal test. The high temperature coke used in these tests was gas coke, but there seems to be little doubt that good figures could be obtained for oven coke. Since coke has a higher radiating efficiency than coal, less of it need be burnt for the same heating service, and economy is therefore realized.

It is desirable that the members of this Society should give a trial to these coke grates for their wider adoption is dependent on personal demonstration. The cost of adaptation is so small and the economy in use being great, the capital cost is soon recovered. Members can therefore render a real service to the cause of smoke abatement by installing a grate in their own homes.

The size of coke used in coke grates is usually nuts of approximately 1 to 2-in. size, the nuts of ordinary oven coke

COKE OVEN FUEL.

being used. But little attention has as yet been paid by the coke-oven industry to the production of the most suitable coke for coke fires, but smokeless fuel committees have recently been formed by the different sections of the Coke Oven Managers' Association to consider the question. Some experimental work has also been done at the Fuel Research Station. There is little doubt that the quality of oven coke for coke fires could be improved by reducing its ash content and ensuring that the moisture content was never excessive. Size is likely to be as important a factor as it is in closed stoves. Milner, Dyde and Hodman (*loc.cit*) have shown that high porosity is desirable. None of these requirements conflicts with those for blast-furnace purposes (the principal use to which oven coke is put). There is too little known about the importance of reactivity to judge its significance for coke fire purposes. According to Milner, Dyde and Hodsman (*loc.cit*) cokes of low reactivity gave high radiating efficiencies, but the ease of ignition and the time to recover after refuelling is important.

Special cokes of high reactivity can be made in coke ovens. The Barrow Haematite Steel Co. Ltd., at their Barrow Collieries, Barnsley, and the Sheffield Coal Company at Beighton, have produced smokeless fuel of high reactivity by using flue temperatures of only about 700°C. and prolonging the coking time. This is only possible in horizontally flued ovens, those of 21-in. width being coked in about 48 hours instead of, say 32 hours. The product is broken to nut sizes and screened. It is dull black in colour, contains about 10 per cent. of volatile matter, and is almost smokeless. The writer used this fuel in a sitting room grate in the winter of 1931-32, and could claim during that period that his house was smokeless. The well grate used was not entirely satisfactory, the air spaces in the bottom bars being too small, but, with a suitable size of semi-coke, an excellent bright fire was obtained.

Cokes more reactive than the normal metallurgical coke can be produced by blending coking coal with non-coking coal, but it seems more logical to design coke grates to burn the unreactive cokes at present available.

Future Possibilities.

It is important to consider whether a greatly increased demand for coke for domestic use could be met. The production of high temperature coke in either coke ovens or gas works gives for each ton of coal 10 to 14 thousand cubic feet of gas, 4 to 16 gallons of tar, 1 to 3 gallons of motor benzol,

COKE OVEN FUEL.

and 20 to 35-lb. of sulphate of ammonia. In gas works practice, the gas being the main product and coke a by-product, part of the coke is used to heat the retorts so that all the gas is available for disposal, but less coke. In coke-oven practice, the coke being the main product and gas a by-product, part of the gas is usually used to heat the ovens. The recovery of the ammonia as sulphate is not often a paying proposition nowadays, owing to the cheap production of synthetic ammonia and, in the future, less by-product ammonia will be recovered. Omitting this from the products, those available for sale per ton of coal are:—

	Coke Ovens.	Gas Works.
Coke	14 cwt.	10 cwt.
Gas	6,000 ft.	14,000 ft.
Tar	6 gallons	12 gallons
Motor Benzol	2 gallons	*

*Benzol recovery is not made at many gas works.

The high temperature carbonization of much increased quantities of coal to produce coke for domestic use would produce large quantities of other products for sale, but coke ovens are obviously more suited than gas retorts for the production of much increased quantities of coke for a larger yield of coke is marketed per ton of coal, and less surplus gas is available. At present some 40,000,000 tons of coal are used for house heating. Assuming that 40,000,000 tons of extra coke¹ had to be produced in coke ovens the amount of extra coal carbonised would be about 60,000,000 tons and the by-products would be:—

Gas	360,000,000,000 cubic feet.
Tar	360,000,000 gallons.
Motor Benzol	120,000,000 gallons.

The present consumption of motor spirit is about 1,000,000,000 gallons in this country, so that all the motor benzol produced could be used. The tar would have to be used for fuel oil and could be hydrogenated to yield motor spirit without satisfying all the home needs. The amount of gas at present sold in this country is about 330,000 million cubic feet, so that the amount produced in making smokeless fuel to replace household coal would more than meet present requirements. Coke-oven gas is replacing coal gas in many large towns near the coal fields, for example in Sheffield,

¹To meet the present duties at present carried out by coal the amount of extra coke would only be 25 to 30 million tons, but the larger amount is assumed to account for a higher standard of comfort, in which, and the installation of central heating for example, extra fuel demands would be met.

COKE OVEN FUEL.

Glasgow, Newcastle, Middlesbrough, Rotherham and Nottingham, and a gas grid scheme is being initiated in South Yorkshire to collect surplus gas from many coke-oven plants and to use it for many purposes, for which raw coal is at present used. It is anticipated that greatly increased use could be made of gas as a heating agent if the price were sufficiently low. Gas is at present being distributed in pipe lines for several hundreds of miles in Germany and America, the cost of distribution being very low. It is therefore conceivable that a much increased use could be made of gas distributed in long pipe lines all over the country and many gas works could cease to produce gas and concentrate on its distribution. Gas could be made available at low cost in areas where it is now produced on a small scale with high costs. It would find extended use for operations at present using coal, frequently with the production of smoke. Coke-oven gas compressed to 200 atmospheres could be used to replace petrol on lorries and buses. The 350,000 lorries and heavy vehicles using petrol in this country would use about 150,000 million cubic feet of gas if driven by compressed gas. The remainder of the petrol required for private use and motor cycles (about 500 million gallons) would be produced by hydrogenating the tar and using the motor benzol produced as previously described. The use of coke-oven fuel for domestic heating would therefore not only abolish the domestic smoke nuisance, but would enable this country to be independent of foreign oil supplies.

One effect of the displacement of coal by coke would be to raise the price of coke, for at present household coal brings the highest prices of any brand of coal and may be sold at 20s. 0d. per ton at the collieries, compared with only 10s. 0d. per ton for small coal, slack, which is at present used for coke making. A decrease in demand for large coal and an increased demand for small coal would tend to equalise the price realised for each. Since there would not be enough small coal available for the production of an extra 40,000,000 tons of coke, large coal would have to be broken. The prices of all sizes of coal would tend to the same, at near say the average cost of production of coal, namely about 14s. 0d. a ton. This would result in slack for steam-raising purposes being more costly for such coal can be used for coke making when blended with coking coal.

G. W. Foxwell has given figures which show that if a coke making plant is sufficiently large, and a full output can be maintained, coke can be produced at but little more than the price of coal. (Gas Engineering, 1930, Dec., p. 679). For a plant with an output of 10,000 tons of coke per week he gave

the price of coke at 10.7 shillings, made from coal at 10s. 0d. a ton, a credit of 5d. per 1,000 cubic feet being taken for the surplus gas. Thus it should be possible to produce domestic coke at say 20s. 0d. a ton at the coke ovens using crushed large coal, but a market would have to be assured for all the by-products. The coke ovens would have to be installed at the collieries to minimize transport costs. Under these conditions coke would be about the same price as coal is at present.

It is unlikely that such an increase in the coke-oven industry would be brought about suddenly and a gradual change is to be expected. The vision of the production of domestic fuels in coke ovens to meet all the requirements at present met by coal may be the reality of the future. It is quite certain that increased use will be made of oven coke for domestic purposes without any incentive of Government action, on account of the greater efficiency in use, its smokeless combustion, and its cheapness.

Members of this Society by adopting some of the appliances described in this paper will not only gain comfort with economy, but will have a very real satisfaction in promoting the cause of smoke abatement.

DISCUSSION.

ALDERMAN WILL MELLAND (Chairman of the Society) stated that he had used the Manchester Corporation domestic gas coke for the last few years, both at home and in his office, with excellent results. The Manchester Corporation now sold 50,000 to 60,000 sacks of coke per week for use in open fires. He drew the attention of the meeting to the inquiry of the Society on the use of gas coke, which had been reported in the *Journal*. He wished to ask Mr. Mott if the coke oven fuel was suitable for burning in ordinary open grates, and especially in small houses where there are only "two up and two down" rooms—which was the case with one-half the houses in Manchester.

MR. JOHN W. BEAUMONT (Halifax) put in a plea for the more extended use of gas coke for the following reasons: (1) that the supply of coke oven fuel was inadequate in itself to meet the demand for solid smokeless fuel and that gas coke was probably much more generally available; (2) that it behoved them to make full use of all forms of smokeless fuel in their endeavour to get rid of the smoke nuisance. He had not experienced the difficulty in burning gas coke in well grates as mentioned by Mr. Mott, and for two years had burned gas coke in the two sitting room well grates in his own house, with entirely satisfactory results. During that period he had kept a careful account of cost and estimated that as

COKE OVEN FUEL.

compared with raw coal and £2 a ton, he was able to save at least 10% on his fuel bill.

Mr. Beaumont pointed out, as an indication to which this particular form of fuel was used in Halifax, that the equivalent of 30,000 tons of coal was sold annually in the form of gas coke, for domestic purposes. As a further indication of its popularity and the intelligent anticipation of their gasworks engineer, this coke was sold throughout the town in such small quantities as may be contained in a 3d. bag, thus presenting a definite inducement to those of the poorest means to make use of smokeless fuel.

MR. T. E. BIRTWISLE (Sanitary Inspectors' Association) said that such a statement as had been made by Mr. Mott was long overdue, and their best thanks should be accorded him for the information he had placed before the Conference. Speaking from experience, coke produced in coke ovens had been burnt with excellent results in a boiler used in connection with a small central heating apparatus, and it should be possible to extend the practice. The installation described by Mr. Mott was an excellent one, but it was not necessary to provide a double cylinder where cost had to be considered; a single cylinder with an internal tube coil was sufficient for the purpose. He thought, however, that the coke oven people should produce a fuel of less density, and with a much lower moisture content than that now available, which would be comparable with the porous dry coke now being made in vertical retorts at many gasworks.

DR. HEBBLETHWAITE (Sunderland) drew attention to the fact that if coke oven fuel was to be developed in the future to any large extent for domestic purposes, the question of the dangers of burning coke without adequate means of ventilation should be made fully known. He instanced two cases, one in domestic consumption, the other in commercial consumption.

As regards the former, he instanced the practice common in domestic kitchens of servants removing the top ring of a coke stove in order to heat pans of water quicker than by placing them merely on the top of the closed stove. Afterwards, the top of the stove was not always replaced and dangers arose owing to servants sitting in kitchens heated by a coke stove under such conditions, which allow dangerous carbon monoxide fumes to enter the kitchen.

As regards the latter, Dr. Hebblethwaite stated that he had recently been concerned with the passing of plans for a large cinema, of which the boiler house was situated below and to the rear of the stage, to which it was connected by a series of corridors. Two boilers burning coke fuel were served by a chimney of suitable height, and the boiler house was ventilated by two small air grates. This means of ventilation was not considered satisfactory, but the engineers in charge of the construction of the building gave the assurance that

the draught of the chimney would eliminate any possibility of down draught occurring.

A few weeks later, however, the boiler attendant burnt in the furnaces, paper, chocolate boxes, shavings, and other refuse from the cinema. Immediately afterwards the front half of the auditorium was enveloped in visible smoke and pungent fumes from the burning material. A down draught, therefore, had occurred, and it was obvious that invisible and odourless fumes of carbon monoxide could also have penetrated into the auditorium. It was not until the connecting corridors between the stage and the boiler house had been effectively blocked up, the outer ventilators had been considerably enlarged, and an arrangement by which fresh air was drawn into the boiler house by means of an electric fan, that the Medical Officer became re-assured that all dangers attendant upon the use of coke for commercial purposes were prevented.

DR. A. BARHAM STICH (Gateshead Insurance Committee) said that he had, some six years ago with the object of contributing his own bit to the problem of smoke abatement, dispensed with his kitchen range and installed a coke boiler to which were coupled four radiators, forming a partial central heating installation; the coke boiler serving also for the supply of hot water. All cooking was done by gas. The local gas company's coke was first tried, but gave considerable trouble because of its high ash content, which made it impossible to keep the fire burning continuously as is necessary if the benefits of central heating are to be secured. The type of coke boiler he used works efficiently, of course, with anthracite, but this was too costly in the north, and his attention was drawn to oven coke as a fuel, and he had now been using this (1½" nuts) with satisfaction for several years. But even this from time to time gave trouble. If combustion was allowed to proceed briskly to minimize the risk of the fire going out, the water boiled, and if the fire was damped down too much it would go out. His experience had been that it was difficult to get maids to give sufficient attention to the fire to obviate these difficulties. From its very nature the minimum temperature of the coke fire must be kept fairly high if combustion was to be continuous, and there was in consequence a very small margin of error between overheating and the cessation of combustion, but on the whole coke oven coke had given satisfaction. Dr. Stich added that an anthracite stove was used in the main living room, and electric fires in the bedrooms. He urged that a fuel should be introduced which would kindle more readily, and that the keeping in of fires be made no more difficult than with ordinary fuel.

MR. FRANK P. TARRANT (Newcastle upon Tyne and Gateshead Gas Co.) said that it would be regrettable if the meeting dispersed with the idea that only coke produced in coke ovens should

COKE OVEN FUEL.

be used for domestic purposes: most gasworks endeavoured by means of selected coals and grading of coke to put on the market coke suitable for the purpose. The undertaking with which he was connected, and many others, were producing coke from vertical retorts which was very suitable for use in an open grate, and it would be a serious matter for small householders to remodel grates at their own expense on the lines suggested by the author of the paper. One speaker referred to the inferior quality of coke received from his company, and he could only say that he must have had a particularly bad sample, and it was rather remarkable that he should also complain about coke received about the same time from coke ovens.

If gas coke was properly "sized" for the purpose required the formation of heavy clinker would not take place, although it must be remembered that the ash content was dependent upon the coal used. Serious attempts had been made during the last two or three years by many local collieries to reduce the ash in coal, by the introduction of screening and cleaning plants. There was one other point to be remembered—that all gas undertakings would view with great concern the going out of any idea that coke ovens should be put down primarily to produce domestic coke, because a great amount of capital was already invested in the gas industry and in such case this capital would no longer be remunerative.

MR. J. McNICHOLL (Newcastle-upon-Tyne) said that there was an impression, which was widespread among the public, that the fumes from coke fires were more dangerous than those from the ordinary coal fire. He had not sufficient knowledge of the subject to state whether or not this was so, but assuming that it was correct, what would be the effect of using coke where there was a down-draught in the chimney flue? He had in mind a certain street of houses, on one side of which the chimney stacks had been built up to twice their original height and almost every type of down-draught preventer on the market could be seen fixed to the tops of the chimneys. In spite of this, during certain winds the houses still suffered from down-draughts. With a coal fire this was early evident, but this would not be so in the case of a coke fire and would therefore be more insidious.

MR. E. M. MYERS (Messrs. Dorman Long) said that he had been asked by Mr. J. A. Davy, the President of the Coke Oven Managers' Association, to speak on his behalf. The paper presented by Mr. Mott was of the usual very high standard that the Coke Oven Manager were accustomed to receive from him, and he would like to add his praise to that of the previous speakers, for Mr. Mott's work. They would not, however, like the public to imagine that the coke oven industry was the only one that could supply coke for domestic purposes, for the gas industry, to which they were so closely

allied, could also meet those requirements, and they felt that there was ample scope for both.

He would like to correct any wrong impression that a previous speaker might have regarding the moisture in coke oven coke, for hundreds of thousands of tons were made annually to very definite specifications which called for a moisture content not exceeding 2 or 3 per cent., which figures were in line with the natural moisture of the coal. His figure of 10 per cent. or more could only be regarded as an isolated case, for such a moisture content would not be tolerated by the blast furnace industry or the ironfounding industry, both of which consumed very large quantities of oven coke. There were just two points in the paper to which he hoped Mr. Mott would not mind his attention being drawn. Firstly, reference was made to the production of special cokes in coke ovens which, he stated, were only possible with horizontal flued ovens. This was not strictly correct, for Mr. Myer's Company were producing similar coke in vertical flued ovens for which process they held a patent. By this process any coke oven plant could be adapted at will, either wholly or in part, to produce domestic coke, and they would be pleased to supply particulars of this to anyone interested. Secondly, with regard to the supply of gas for town and domestic purposes referred to, he would like Mr. Mott to include Middlesborough, which was the first town in the country to purchase coke oven gas in bulk, and which now took the whole of its supply from this source.

Mr. Myers congratulated Mr. Mott on his paper, and trusted that the points which he had so lucidly demonstrated would considerably help forward the policy of smoke abatement.

MR. THOMAS ASHFORD (Glasgow) desired to associate himself with the previous speakers in their general expression of appreciation of Mr. Mott's most interesting and illuminating paper, more especially as the question and search for suitable types of non-bituminous fuel, which would prove themselves satisfactory for ordinary domestic use, was one of the pressing problems in the campaign to solve the domestic smoke menace. Mr. Mott had dwelt somewhat exhaustively on various types of appliances apparently very suitable for ensuring adequate combustion of both gas and coke oven fuel, but Mr. Ashford was afraid he had been prone to confine his descriptions and suggestion to fire grates more suited for the well-to-do household. When one considered that undoubtedly most of the smoke from domestic sources was emitted from the chimneys connected with working-class districts and smaller houses of restricted means, he felt that some of the suggestions were not quite applicable to this type of house.

It was quite true that coke fires could be quite efficiently kindled by the methods described, that is, grates fitted with permanent gas

COKE OVEN FUEL.

jets under the fire bars, and also by the use of the portable gas poker, and, apart from the question of the mass installation of these aids to ignition, it was common knowledge that the usual grade of coke required a considerable time before it was sufficiently ignited to be of much practicable use as a heating medium. The average housewife had neither the time, much less the inclination, to spend, say, three-quarters of an hour of her precious time in the mornings preparing breakfast for an impatient, not to mention exasperated, husband.

In the course of his duties as a smoke inspector Mr. Ashford was the recipient of probably half-a-dozen complaints weekly from somewhat disappointed householders as to how ordinary coke fires could be more expeditiously kindled in the mornings. It seemed to him that the average sample of coke, either from oven plants or gas works, containing as it does say from $1\frac{1}{4}$ per cent. to $2\frac{1}{2}$ per cent. of volatile matter and consequently very inert, would not be a solution to the use of the domestic component of the problem. As the use of low temperature carbonized fuels of higher volatile content was not likely to become general in the immediate future, possibly for commercial reasons, what was wanted was a high temperature coke having a volatile content of 5 per cent. and over, if the bugbear of the difficulties of reactivity to ignition was to be solved. He was of the opinion, based on practical observations and tests, that this factor was of much greater importance than the texture of the fuel.

MR. JAMES LAW (Sheffield, Rotherham and District Smoke Abatement Committee) said that as a practical smoke inspector, the use of coke oven fuel for domestic purposes was not a practical proposition. What was required most, was a fuel easy to ignite and easy to burn in any type of existing fireplace, and one that was competitive in price with coal. In Sheffield there were about 125,000 fireplaces. What would be the cost of converting these into suitable fireplaces for coke oven fuel? The prices ruling at the present time were 28/6 per ton for house coal, and 32/- per ton for coke oven fuel, so that the difficulty was not only one of converting fireplaces, but also one of competitive prices.

MR. R. A. MOTT, in reply, said that he was interested to hear of Mr. Beaumont's success in using vertical retort gas coke in an ordinary well grate. In answer to Alderman Melland, oven coke had to be used in a suitable grate and under such conditions gave a satisfactory performance. He was unable to record any personal experience containing oven and gas cokes in open grates. In reply to Mr. Birtwisle, oven coke could be produced of lower density and there should be no difficulty in ensuring a moisture content sufficiently low. He was aware that central heating and domestic hot water production could be carried out with one boiler and without using

double cylinders, but he did not think that this method was as satisfactory as the one described in the paper. He agreed with Dr. Hebblethwaite on the importance of ventilation and mentioned that he had arranged that when the top cover of a coke boiler in his house was removed for boiling pans, the draught damper should be fully opened, the need for this being easily demonstrated on burning some paper at the top. In reply to Mr. Stich, there should be no difficulty in keeping a central heating boiler in overnight, the secret being to riddle out the ashes the last thing at night, ensure that the bed had settled down and charge coke until no more could be pushed in with a rake from a hod held against the charging door. The coke should be as large as will settle readily in the boiler since a large size facilitates good packing, but, the smaller the size the more readily it fell as the lower layer was burnt away. He would recommend $1\frac{1}{2}$ - $2\frac{1}{2}$ -in. size and a smaller size 1-2-in. if this did not fall readily. He agreed with Mr. Middleton that invidious distinctions between gas coke and oven coke were unnecessary and that concerted action on the part of the producers of the two types of coke was desirable. He agreed with Mr. Smith that a cost of 9d. per day was too much for working class houses, but this referred to central heating which was recommended for medium-sized houses. A coke-fired boiler and oven would use 25-lb. of coke per day, which at 30/- per ton would cost 4d. a day, which would meet the needs of those living in small houses.

THE PSYCHOLOGICAL EFFECTS OF ATMOSPHERIC POLLUTION.

by

ALDERMAN DAVID ADAMS, J.P., Chairman, Health Committee,
Newcastle upon Tyne.

The invitation to write this paper emanated from the Secretary of the National Smoke Abatement Society, Mr. Arnold Marsh. The ingenuous writer of it ignorantly imagined that this person of weight, and well learned in the history, tradition and romance of smoke from the days of Tubal Cain onwards would readily provide abundant data upon which the said writer might plagiarize the above subject as an original contribution. But this illusion was soon shattered! Enquiries of the Department of Scientific and Industrial Research which is carrying out research "into the nature of pollution and the best methods of measuring it" revealed the fact that they possess no scientific data upon the above. The Department, however consulted the Medical Research Council and the Ministry of Health upon the enquiry. As a result "it was ascertained that the Medical Research Council has promoted no work on the psychological effects of atmospheric pollution, and neither they, nor the Ministry of Health, have any information on this subject readily available."

Application was then made to the Royal Society of Medicine, which maintains the finest library on medicine and associated sciences in Europe, and also specializes in the preparation of lists of references. A reply was received that they had only discovered one small reference in the Journal of the Royal Sanitary Institute, where mention was made of the depressing effects of smoke, but they considered it of so little consequence that they did not suggest it should be consulted. However, the Royal Society of Medicine mentioned that there is some interesting literature dealing with the physiological and psychological effects of Tobacco Smoke, and a list of references followed.

As, however, this Conference is not concerned with the pernicious habits of the President and other officers of this Society in this connection, no further use has been made of the references mentioned, excepting to place upon record for

THE PSYCHOLOGICAL EFFECTS.

the benefit of the said President and officers of the National Smoke Abatement Society the opinion of one, H. H. Tidswell, who regretted that he had acquired the habit in the Medical School of St. George's Hospital, and considered that "it may truly be described as suicide or self-destruction by early instalments," and regards it as "a form of narcophilia, which may soon develop into narcomania, dulling the intellect, and poisoning their wives by their smoky breath, thereby causing sterility."

In 1849, one of Dr. Thos. Hodgson's sisters, aged 16, confirmed this view by writing—

"How those who use fusees
All grow by slow degrees
Brainless as chimpanzees
Meagre as lizards.
Go bad and beat their wives,
Plunge (after shocking lives)
Razors and carving knives
Into their gizzards."

Letters were then addressed to the following:—

1.—INDUSTRIAL HEALTH RESEARCH BOARD OF THE MEDICAL RESEARCH COUNCIL.

In reply they forwarded a list of catalogues, which, however, had references to work under conditions of increased humidity, high temperatures, etc.

2.—NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY.

They replied as follows:—

"We have carried out no research on the psychological effects of smoke pollution, and I regret that we have no information on the subject, except in so far as it is involved in the whole question of the effect of good lighting on health and efficiency. Abundant evidence on the latter point will be found in our newly published book 'Industrial Psychology in Practice' (Pitman 7/6)."

3.—PROFESSOR OF INDUSTRIAL MEDICAL PSYCHOLOGY (MILLIAS CULPIN, D.M., F.R.C.S.), LONDON SCHOOL OF HYGIENE, LONDON.

The following is a copy of the reply received:—

"Your letter arrived when I was on holiday. I have hunted up any possible references and can find no hint of any investigations into the psychological effects of smoke. It seems difficult to plan any research in which the necessary controls could be established, and I am

THE PSYCHOLOGICAL EFFECTS.

rather impressed by the difficulties we meet in examining into the related question of the effect of noise, where expressions of opinion are frequent, but evidence difficult to obtain.

I should like to help if possible. Perhaps you could give me an indication of what has been observed or conjectured on the subject of atmospheric pollution of this nature."

A search has been made through the various text books and publications on smoke pollution with a view to discovering whether anything had been said regarding the psychological effects of smoke. With the exception of one small paragraph in a standard American Work ("Preventive Medicine and Hygiene" Rosenau) the search was entirely futile. The paragraph is full of enlightenment, however, and reads "Indirectly smoke is a source of dirt and general nuisance and leads to depression of the spirits."

In consequence of the failure of his enquiries the writer concluded that living in an economic age when the purse outweighs all other considerations it were but natural to find that there is abundant scientific data available relative to the effects of smoke and other atmospheric pollution upon buildings, growing crops, productive enterprise and other monetary considerations, and little or none upon the psychological effects upon the individual citizen.

In any event the greatest ill suffered by dwellers in smoke-laden centres is their deprivation of the sun's natural rays.

The psychological and physiological ill-effects of adverse atmospheric conditions are indeed inter-related, and the losses to the nation, in wealth, comfort and happiness therefrom, almost incalculable.

Therefore, in any consideration of the psychological effects, the physiological must also be brought under review. It is a simple truism to state that a healthy body produces a healthy mind, whilst conversely a depressed state of mind inevitably lowers the physical standard of the body.

There is little question that the cradle of the human race was not in these islands. The first Roman invaders, through Caesar in his *De Bello Gallico*, recorded their doubts as to the capacity of this new province to grow corn, as it appeared to them to be continually steeped in mist and fog, and largely bereft of the golden orb of heat and light. Britain would indeed have proved too sunless for our first parents and their omnivorous offspring. Our first settlers were emigrants from other climes. The human family could only have originated where the sun wrought his beneficent way upon a fruitful

THE PSYCHOLOGICAL EFFECTS.

tropical earth. Only in this environment could the emerging races have found easy and plentiful subsistence from the animal and vegetable kingdoms in forest, field and flood.

Worship of the sun was general and deeply enshrined in the religious faiths and practices of all early peoples. We know that at the hands of their Spanish conquerors the Incas chose death at the stake rather than abandon for Christianity their ancient faith in the sun as the supreme life giver, the unchallengeable deity of the Universe.

It may be of interest to the strangers within our gates to know that traces of fire worship still prevail in Northumberland. It is the perennial custom at Whalton when the last of the harvest has been gathered in, to light the bale-fire in the darkening village street, and for the country lads and lasses to leap through the flames.

To-day led by the priesthood of the medical profession, especially those extreme votaries of it, the Medical Officers of Health, we are returning to that most ancient of faiths, the worship of the Sun, in the ceremonial of interblending his vital rays with our receptive bodily framework.

In pursuit of their ideal these crusaders labour in two specific fields to give more light to the race:—

- (1) by the restoration of the sun's rays to town populations in the removal of obstructing media—smoke, fumes, grit, and other products of combustion.
- (2) the clinical use of ultra-violet rays, made available by the giant strides in electrical science. In the sphere of preventive and curative treatment of sickness and disease, the potency of sunlight is being daily preached, and slowly recognised.

Dr. Veitch Clark, Medical Officer of Health for Manchester, with others, has sounded a clarion call to arms. Few will deny his contention that “the abolition of smoke from our midst would do as much for the improvement of public and individual health in our industrial centres, as any other single action open to this country.”

Man is a sun animal, and not only in external influences but, in his subsistence also, sunlight was destined by nature to play a leading part.

The new science of Vitamins effectively demonstrates this latter. This is well illustrated in the case of Cod Liver Oil. In the oceans are myriads of animalcules named Plankton, which living on the surface of the sea absorb the ultra-violet rays of the sun. These Plankton are consumed by small fish,

THE PSYCHOLOGICAL EFFECTS.

and upon these latter, in turn, the cod feed. Thus, ultra-violet rays are stored in cod in the form of vitamins, particularly in the liver of the fish, from which the oil is extracted, to be used as a source of vitamins which are known to be essential for the growth and development of the human body.

How essential the sun's rays are to the human body may be further illustrated by the fact, recently established, that these rays are directly concerned in the manufacture of at least one of the vitamins in the human body. It is found that there is an inert "provitamin" in the human skin, which is converted into an active vitamin by the sun's rays, and is thus made available for utilization by the tissues of the body.

As all are agreed to-day, the proper functioning of the body cannot be maintained without the presence of these vitamins. The sun's rays are heaven's free gift to mankind. Thrice cursed be those who rob us of this birthright!

It is immediately apparent from this that we must remove the industrial pall which shuts from us the life-giving action of the sun. When, therefore, to-day we are all agreed on the absolute necessity of a maximum use and enjoyment of sunlight for our normal life and development, what folly it is to pour into the vital air we consume thousands of tons annually of coal smoke, and the residues from raw coal and chemicals.

Is there any question that under proper social conditions and guaranteed the full measure of the sun's influence, human life would be vastly prolonged, and the joys of existence greatly augmented?

The day is not far distant when to burn raw coal in the domestic grate or factory furnace, or otherwise to pollute the atmosphere, will be recognized as one of the serious crimes against the community.

Industrial psychology has discovered by scientific study and experiment a wide diversity of exact data, the practical application of which is of the utmost importance in the sphere of efficiency and well-being. A new revelation, indeed, has in this field been evolved for the use of our changing industrial age. What, therefore, may the scientific study of the psychological aspects of the smoke problem reveal to mankind?

We live in a world where ills of the spirit are all too common. Fears and obsessions and phobias of one kind or another are part and parcel of our hurrying civilization. There are some who fear high places or solitude, others again are imbued with "agoraphobia"—the fear of public speaking, which may be either active or passive, but the all prevalent obsession of the present day multitude is that fear of being

shut in, closed in, crowded together, which is called "claustrophobia."

Is it too much to suggest that we, all of us, living in great cities suffer a little from that "claustrophobia," which may be due in part to the overhanging immensities of our Paramount Theatres and Temples of Commerce, such as our own Carliol House, but is caused in much greater measure by that pall of smoke which shuts us in from the sky and the sun? From these fears man must seek relief and escape. He does so by pursuing sophisticated pleasures. The theatre-going crowd of Manchester is a revelation to every visitor within that city. But this method of escape from the pall of smoke, and its attendant "claustrophobia" is only a palliative.

Let us think, not only of the physique, but of the mental freshness and the vivid outlook on life of those whose lives are spent in sunnier places. The comparison is to our detriment. We are losing something, bodily, mentally, spiritually, but how much?

Here, indeed, is a wide and virgin field for investigation by the psycho-therapist. His findings may well reveal the hitherto unsuspected causes of many of the problems which workers in preventive medicine are to-day striving to solve.

DISCUSSION.

MR. CHARLES GANDY (Manchester Branch) contrasted the cheerful influence of light with the depressing effect of smoke, particularly on those whose homes were, among streets and buildings which had become dark, dingy, and colourless by long exposure to it. The endless struggle against dirt due to a smoky atmosphere was enough to break the hearts of the women in such homes, and perhaps more than overcrowding or actual dilapidation tended to the "moral and spiritual degradation" which he had heard described as the worst feature of slum life. He pointed out that on most days in our big cities the greater part of the light which we are able to enjoy was reflected light, and if we allowed our buildings as they grew taller to remain soiled and blackened by smoke, almost the only light left would be what is reflected from the sky high above us. Clean buildings would reflect light and besides making our streets more cheerful by day would make our cities generally more attractive to visitors, and the psychological effects of that might be stimulating to our general prosperity. In Paris and other continental cities where the smoke nuisance was considerable the law required the owner of every building to clean the whole exterior thereof, including stone and

THE PSYCHOLOGICAL EFFECTS.

brick work at least once in every ten years, and the enforcement of this law received general approval. Would it not be worth while to consider the adoption of a similar practice in this country? He also suggested that the wages received by workers, the lives of whom and of their families were deprived of natural light and colour, with a constant struggle against dirt and ill health, do not go so far in the purchase of real well-being as the wages of persons, e.g., agricultural labourers in this country or some industrial workers abroad, who were better situated, and that therefore smoke had its effect on our wages problem.

ALDERMAN WILL MELLAND said that the psychological aspect of the smoke evil was quite a new one for the consideration of the Society and seemed to him very important as it entered much more largely than most people thought into the question. The habits of our people had a great deal to do with smoke abatement and everybody acknowledged that to change the habits of a nation was extremely difficult. Take for instance the question of the open fire, to which they were so firmly wedded. It had never been the policy of the Society to try to suppress the open fire, as we were consequently striving to encourage the production and consumption of the smokeless fuels which could be burnt in existing grates.

Naturally it was impossible to set out the claims of the psychological side of the question by the same methods one used in dealing with the technical side, and this aspect of the question could not be treated by ordinary laboratory methods.

Abroad, where the smoke nuisance practically did not exist, it was generally admitted that the people were gayer and had a happier appearance, and though this might be to some extent due to the difference between the Latin races and the Anglo-Saxon, he believed that a good deal of it was due to the absence of smoke pollution and the consequent much more abundant supply of sunlight; and probably the drinking habits of the English people were to some extent due to the conditions in the industrial areas. It would generally be noticed that the English, both men and women, dressed in rather sad colours compared with the brighter colours seen abroad; and the discoloured buildings and cities were bound to have a depressing effect on the population. Then, in what might be called slum areas in such cities as Paris and Brussels, there was a note of picturesqueness in spite of the poverty, owing to the cleanliness of the people; and the buildings formed a marked contrast to the congested areas in their own country.

DR. R. VEITCH CLARK (Manchester) said that the psychological influence of gloomy skies in our cities was probably responsible for much more than was realized even by many advanced thinkers. It would be generally conceded that brightness stimulates and dinginess depresses.

THE PSYCHOLOGICAL EFFECTS.

The Industrial Fatigue Research Board had shown that efficiency in work was lessened by bad lighting and improved by good lighting. But beyond this we had in our racial life many indications of the value of brightness to us as human beings. Our language—one of the greatest inheritances of our race—was full of examples showing our joy and light. Everything appertaining to freshness of spirit was described in terms of light; depression and grief in terms of darkness:—The schoolboy's "shining, morning face;" Lesbia's "beaming eye;" "Weeping may endure for a night but joy cometh with the morning" and many other instances on the one hand, while on the other he need only remind this gathering that "dark care rides behind the horseman."

There were no laboratory scientific proofs to his knowledge which could be brought forward (at least as facts established in the ordinary physical sense) in support of our belief in these influences. Nevertheless we had before us the great change in the physical interpretation of the meaning of matter which had taken place in the scientific world during the present generation.

Matter was no longer the inert, lifeless substance which it was once believed to be. Matter was a manifestation of energy. It was in fact one of the forms of energy. It would therefore be surprising if our physical and mental well-being were not subject to a very marked degree to the influence of such a universal form of energy as was light; and that if we lacked the stimulus of fresh sunlight and daylight, the natural environment of man, there should result a lowering of the general efficiency of manhood and womanhood.

We knew that this lowering was in specific cases evidenced by the onset of various diseases, of which rickets and tuberculosis were the outstanding examples. There was no sharp break in nature. One of the fundamental laws of nature was the law of continuity and it was certain that such definite physical results through the deprivation of sunlight were only the individual proofs of a more widely-spread influence producing a lowering of our entire individual well-being.

MR. T. E. BIRTWISLE (Sanitary Inspectors' Association) said that it was with great diffidence that he entered into a discussion of the paper to which they had just listened. The subject had been lifted on to a higher plane than that from which they had been accustomed hitherto to look at it.

As one who had worked for many years in industrial areas he had always been impressed with the soul deadening effects that must be felt by those who were condemned or compelled to live in mean streets in a smoke laden atmosphere. But what could be done to give practical effect to the sentiments expressed so admirably by Alderman Adams? There was little hope of anything being done with the present generation; salvation lay with the young. He observed that

THE PSYCHOLOGICAL EFFECTS.

the modern school curriculum included courses of instruction in housewifery, and suggested that the great education authorities throughout the country be circularized by the Society asking that instruction in methods of abating domestic smoke be given to the senior pupils taking such housewifery courses, and thus show the rising generation how they could help themselves in this matter.

COUNCILLOR C. E. KEENE (Leicester) considered the physiological effects of smoke on the human being were bound to be detrimental because of the depression caused by it, and that his business experience in Lancashire, Yorkshire and Leicestershire visiting, as he had to do, the poorer class of people daily in their dwellings, proved this to him. The heart-breaking work of trying to keep clean their homesteads, their children, and themselves, made it, no wonder, that this class of person took to drink to escape the effect of their condition and to bring, as they thought, pleasures into their own lives.

He also emphasized the fact that we should cease spending our time upon the middle-age, and that the Smoke Abatement Society should get into touch with the teachers of the Elementary Schools, and by posting them facts relating to the effect of smoke, not only upon buildings but upon human beings, they would be beginning at the right end. He believed they should find very many teachers who would gladly take up this cause, when the opportunities arose in the lessons. They were indebted to Alderman Adams for opening up this new line of thought, and he was one who believed that it would have, if pursued, even greater effects than telling people that smoke fumes, etc., destroy buildings and cabbages.

Might he say that his impression of the conference as a whole was that the papers and discussion were of a high order, and he proposed at every opportunity to use the papers.

COUNCILLOR W. BROWNHILL SMITH (Scottish Branch) congratulated Alderman Adams on his excellent address, putting before them a phase of the subject that has been too little thought of.

At the Annual Conference of the Scottish Branch of this Association, held at Glasgow on May 5th last, one psychological effect of bad atmosphere was described by Dr. Elizabeth Mudie, of Skelmorlie, who spoke of the ill effects in maternity cases, where the anxiety and depression of spirits of the expectant mother were greatly intensified by an atmosphere made dark and disagreeable by smoke and the cheerless view from her window of begrimed buildings, and even in her room the smuts that came in whenever the window was open.

MR. W. F. T. PINKEY (Newcastle upon Tyne Electric Supply Co. Ltd.) said that in an effort to make a practical suggestion for the avoidance of the nuisance caused by the consumption of fuel for domestic purposes in open grates, he would like to reiterate a suggestion made at the World Power Conference in London a few years

THE PSYCHOLOGICAL EFFECTS.

ago:—"The solution of the problem might be found by a suitable legislation on the lines that no new residences erected should be equipped with the type of open grates now in such general use, and further, that such open grates in residences already in existence should, over a period of years, be replaced by one or other of the several systems which are designed specifically for the purpose of preventing nuisances from products of combustion."

A year or so ago he advised the Newcastle Corporation that in his own residence he contributed nothing in the way of smoke whatever to the dirt of the City, nor did he contribute any of the harmful products of combustion. He suggested that this might entitle him to a remission of some part of his rates. Although no reply was received to his application, the suggestion was one which might very well receive consideration.

It should be possible to find out in a city what was the annual cost to the rates resulting from the harmful products of combustion in domestic premises; to arrive at a cost per premises per annum and still be on the safe side by allowing a remission in the rates of, say, half the amount arrived at, to premises where no contribution was made to the cost incurred due to this cause.

Alderman Adams in his paper had referred to a large building, Carliol House, in the structure of which there are no chimneys at all, and which, of course, contributed nothing to the dirt of the city resulting from the heating of the building. In the case of this building, and of others similar, this freedom from dirt contribution must have definite value to the city.

Even a small remission of the rates would have a very big psychological effect—or perhaps better described as a publicity value—to the residents and others, and would give considerable encouragement to those who were endeavouring to find means to avoid the harmful products of combustion in the open grates.

MR. GEORGE BOWEN (Ashington) said that the industrial towns of Ashington, Wallsend, Glasgow and Sheffield were amongst the most filthy towns for smoke nuisances. Ashington, because of the varying hours worked by the miners and their families which necessitated coal fires burning the 24 hours each day, and in consequence a large amount of domestic smoke. In addition, millions of tons of mineral brought from the mines and tipped on a pit heap had been burning for years and the local authority had tried to secure an abatement of the nuisance.

Ash which was deposited in the miner's gardens spoiled the products, killed nearly all vegetation, and even rhubarb withered about 2 years ago. Brasses and steel were quickly tarnished and the paint on doors and window frames was destroyed. Doors and windows had to be closed when a north wind was blowing as the fumes from the heap were abominable. The air in the mines was damp and

THE PSYCHOLOGICAL EFFECTS.

impure, owing to fumes from explosives and stone dust which the miners inhale, and this, together with the fine dust, etc., deposited in the district from the burning heap, was, in his opinion as a layman, mainly responsible for the chest complaints from which miners suffered.

MR. R. H. CLAYTON said that a psychological effect might well influence progress in industry. During his many visits to the industrial areas on the continent he had been impressed by the great cleanness of the works, in comparison with those in our own industrial areas. It appeared to him that in starting commercial life the clean buildings and surroundings influenced the outlook of the young sons of the heads of works, and they took the view that their life interest was in the works. As their parents could and did live near the work this mental attitude was accentuated.

There might be a tendency for young Englishmen in similar positions, who had been educated in beautiful surroundings, and whose parents lived out of the dirty industrial areas, to look upon a works more as a means of making money; a wrong attitude of mind in the development of industry.

SIR THOMAS OLIVER, closing the discussion, said that fifty years ago it was common knowledge that the trees in Sandyford and Jesmond Vale were dying, and as the decay had commenced at the top, the opinion was that the trees were being killed by the smoke and emanations from the chemical factories on Tyneside, at that period in full activity. The decline of the chemical industries had been followed by a healthier arboreal life in the area he had referred to.

During the protracted Miners' Strike of 1926, when little coal was being consumed on the domestic hearths, and in the factories on Tyneside, it was the experience of the residents that they had an unusually clear and extensive view of the surrounding country, lit up as it was by the sunlight, a panorama and a visibility to which they were unaccustomed. There was no longer a heavy pall of smoke hanging over the countryside, so that, while visibility had improved, the residents for the time being were breathing a purer and a healthier atmosphere.

However much in recent past days they had railed against the chimney stalks of factories belching forth volumes of dense smoke, there were many persons to-day, who, from an industrial and social point of view, would welcome once again the effluence of smoke from factory chimneys, not in the form of dense black clouds, but in a flimsier and more delicate form, regulated and controlled by measures for their abatement. Was not the industrial tragedy of the North of England to-day attendant upon the comparative absence of smoke,

THE PSYCHOLOGICAL EFFECTS.

to which we had grown accustomed, and the hushed sound of the hammer on the banks of its rivers?

The amount of soot which fell upon a town was a measure of the unburnt carbon present in the atmosphere. This might cut off as much as 1/6th of the sunlight in summer and as much as half in winter. If they took 100 as the index, and in some of the remote parts of the Highlands of Scotland and the West of Ireland it might be even less than this, the pollution of the atmosphere as represented by the analysis of the rain water was for London 750, for Newcastle 1627, and for Glasgow 2571. As far back as 1648 the citizens of London unsuccessfully petitioned Parliament to prevent the importation of coal from Newcastle on account of the smoke it created. It was not alone the presence of particles of unburnt carbon in smoke which was undesirable, but the fact that besides carbon dioxide there were other acids, such as sulphurous and sulphuric, also in addition ammonia and mineral matter, such as iron and lead. Speaking for himself and his colleague, Mr. Bloxam, Dr. Dunn at yesterday's meeting had drawn attention to the large amount of mineral matter found in the soot of Newcastle, e.g., lead, copper, zinc and arsenic, all of which had as their source the combustion of coal. They had no collective and authoritative knowledge of the harmful effects of these minerals upon the residents in a town, but Delepine in giving evidence before the Royal Commission stated that as he had found in soot from coke ovens near Manchester from 0.4 to 0.5 per cent. of arsenic present, he attributed the decay in the vegetation of the district to the presence of the metalloid, and remarked that arsenical coal when burned was more irritating to the lungs than pure coal, and more likely to induce pathological changes in the lungs.

One of the indictments against the presence of particles of carbon in smoke was that they shut out light and must therefore have a lowering influence upon the health, the energy, and the spirits of the people. We reflected in our lives gloom or brightness within limits according to the amount of sunlight without us. Soot contained more than fine particles of unburnt coal. One thousand pounds weight of coal contained 8-lbs. of sulphur; and during combustion part of this became changed into sulphurous and sulphuric acids and these, particularly the latter, had a strongly corrosive action upon buildings. During Sir Thomas's visit to Pittsburgh a few years ago, he was much impressed by the worm-eaten appearance of the front of several of the buildings in that smoke-laden city; also in his visit to its University on scanning the analysis of the atmospheric air to be informed of the several tons of soot which fell upon the city annually; and in visiting the pathological museum to see in jars the large handfuls of carbon which had been collected from the lungs of men and women who had lived in Pittsburgh. Until provided with the actual evidence of the carrying amounts of carbon it was almost

THE PSYCHOLOGICAL EFFECTS.

incredible that the human lung could harbour so much carbonaceous material.

Fifty years ago, when he became a physician to the Newcastle Infirmary, it was not uncommon to have in the wards coal miners suffering from miners' phthisis and who in the course of the day would fill, once or twice, a spittoon dish with liquid expectoration, known as "black spit." After death the lungs of these patients were found to be coal black in colour and to be of heavier weight than the average, also from the lungs when compressed large quantities of a thin black ink-like fluid would escape. The lungs had become black, not only from the men having inhaled fine particles of coal dust, but also from the smoke emitted from the miners' lamps. All this had, practically speaking, disappeared, and the vocation of the miner has become more healthy, thanks to the introduction of the two shaft system of ventilation.

The harmful effects of smoke, although not always discernible, were direct and indirect. It was the indirect effect of smoke upon a community which could not be ignored. By shutting off some of the sun's rays the spirits of a people became depressed, muscular fatigue was more readily induced and lasted longer, there was greater mental apathy, nutrition generally was impaired and vegetable vitality was lowered.

Apart from the economic waste, which excessive smoke represents, they, as a people, had to face the fact, that they were living in an industrial age with problems peculiar to itself, many of which were social. Experience confirmed the fact that the fulness of life did not depend upon the abundance of material things they possessed, but upon the right use they made of them. Years of commercial progress had not altered the feelings of the people, that whatever may have been during this period, the material gains through industrial prosperity there were yet the spiritual values of life which had to be considered. It was this aspect of the question which if it had not come much to the front in the discussion this morning, yet underlay the subject they had been discussing.

Sir Thomas Oliver then called upon Mr. A. E. Crossley to present his paper on "The Human Element: A Factor in Smoke Abatement."

THE HUMAN ELEMENT: A FACTOR IN SMOKE ABATEMENT.

by

A. E. CROSSLEY, Senior Smoke Inspector, Manchester.

The Public Health Act of 1875 has now been in operation for 57 years under which all proceedings have been taken for the emission of "Black Smoke" in such a quantity as to be a nuisance. In addition, we have the Public Health (Smoke Abatement) Act 1926, which came into operation on July 1st, 1927, which gives Local Authorities the power of dealing with smoke other than black, with an increase of penalties for either of these offences, but, on the other hand, this later Act increases the number of exemption trades which many of us are definitely of the opinion was a retrograde step and quite unnecessary. And because the majority of Local Authorities have failed to carry out these Acts, we, as a Society, are meeting again to consider the best methods of dealing with this nuisance from smoke which is doing incalculable damage to the health of human life, vegetation, buildings, and everything with which it comes in contact. We can, to some extent, assess the loss to vegetation and the damage to our buildings, the loss it entails in extra laundry bills and to manufactured goods, but the loss caused to human beings we cannot estimate in money value.

Local Authorities are carrying out to a great extent the various sections of the P.H. Act, 1875, and subsequent Acts and regulations with respect to the supply of unadulterated food, a clean unadulterated milk, a pure and sufficient water supply and a fairly reasonable attempt to house the people. But when we consider the air we breathe, which is a vital necessity, and that a man consumes seven times as much air by weight as he does food and water every 24 hours, we find that only very few Local Authorities take any active part in attempting to prevent the pollution of the atmosphere by this intolerable nuisance from smoke. As the fundamental requirements for the elimination of the smoke nuisance are so few, it is surprising that with all our knowledge and experience which has been accumulating year by year, we have made such little progress.

I need hardly express to such a gathering as this the importance of Smoke Abatement, because you are all deeply interested in the subject as shown by your presence at these Meetings, and it is not my intention to offer to you any new principle to achieve this much desired object.

Much has been attempted and much has been done during

THE HUMAN ELEMENT.

the past 30 years in some districts, and as I look back I can see a vast improvement in the atmospheric conditions of some of our cities, but not to the extent that one would desire. Great progress has been made by both the chemist and the engineer, particularly in the years that have followed the Great War. The scientific application by the engineer of the principles formulated in the laboratory have revolutionized steam production and the recognition by steam users that smoke abatement is fuel economy has played a very important part in the results so far obtained. Not only during the trade depression which exists at the present time, but also for as long as the combustion of coal forms the principal method of generating steam for various purposes will the importance of economy in the use of fuel need to be thoroughly appreciated.

It would be useless to give arguments to this meeting in favour of saving coal or other fuels, but the fact remains, however, that in spite of the general opinion that fuel should be economized to the utmost extent, little progress has been made to this end. The large steam generating stations were the first to go carefully into the methods of reducing fuel consumption to a minimum, with a maximum of steam efficiency, and the old rule of thumb methods discarded. The results have been very gratifying. The larger commercial undertakings are now alive to the benefits, but it is with the smaller plant owners where one sees so little improvement. We must always bear in mind that the problems and difficulties of large sized plants are also present in the small plants, the question only being one of degree, and generally what is good or bad for one is similarly good or bad for the other. Whatever type of plant or equipment, we must realize that the human element is still the predominant factor and in spite of all the most modern plant and equipment, it is quite hopeless to expect satisfactory results unless the man responsible for its operation has a thorough grasp of the principles of its operations. It is appalling, but nevertheless true, that with the vast majority of engineers as far as smoke abatement and fuel economy problems are concerned, they are only too willing to write them off as incurable or unavoidable. Perhaps the explanation may be that the engineers are not specially trained in the principles of combustion or that they have little time to make a special study of this important branch of engineering. I admit from personal experience the engineers find that they have such a number of matters to attend to that they find it impossible to devote the time to the boiler house that should be given, but I would also remind the engineer that it is the busy man who finds time to do essential

things, and though he may not be able to do everything, there is a great deal more that can be done in most works than is actually being accomplished.

The tracking down of waste, and heavy smoke emissions are certainly wastage; calls for the exercise of system if it is to be carried out with the greatest degree of success; and for the busy engineer the best plan is to tackle each different point separately and overcome it before proceeding to investigate the best possible cause of bad results. This system will avoid the error of tinkering with the work, of doing a little here and a little there, with no substantial improvement anywhere. If the technical administration of the works is not thoroughly conversant with all matters bearing upon the efficient operation and management of the plant for which they are responsible, the prospect of eventual economy and efficiency are consequently very poor.

In tracing the human element in matters of smoke abatement one is sometimes inclined to think that only the fireman and the engineer are involved, but that is not so, for the human element can be found to be operating as far distant from the boiler house as the directors' boardroom. Where, on a matter of a saving of a few shillings per ton of coal, they decide without full consideration of actual results that a certain fuel shall be used, such policy, short sighted though it be, I should bring within the scope of the human element; and by their action to effect a small direct saving, they will ultimately lose on boiler efficiency is extremely common practice. Such policy if it does not kill all incentive on the part of those engaged in the boiler house, will certainly place an unnecessary handicap upon them in attaining anything like reasonable efficiency.

It is the specific duty of the fireman to use the fuel supplied, but it is also as much the duty of the management to see that it is used under the most suitable conditions, so as to ensure maximum efficiency and not to expect impossibilities. No matter should be regarded as too small or trivial where efficiency is concerned, and should not be dismissed without careful consideration.

Boiler House Control.

During the last decade, modern methods of boiler house management and control have brought the act of steam raising to a level which is envied by the production departments of other spheres of activity in the works, due to the combination of efforts on the part of the engineers who manufacture the plants, to chemical science which has supplied us with

THE HUMAN ELEMENT.

reliable data relating to various fuel values, etc., and to those who are responsible for the operation of the equipment under working conditions.

The continuous operation of a boiler house plant at a maximum efficiency depends on the human element, the boiler fireman, and whether he is attending to boilers automatically fed or hand-fired, he should be encouraged on all occasions to acquire knowledge and be taught to understand the proper method of burning coal or any other fuel to the best advantage. He should not be treated as a mere watchman for the steam pressure and water level gauge, or have an occasional look at the chimney, but he should be an integral part of the whole operation of steam raising or converting the greatest number of gallons of water into steam from a given weight of coal efficiently. Simple tuition and explanation of cause and effect, of thickness of fires, amount of draughts, excess of air or too little air, and the composition of flue gases, will often suffice to change a disinterested fireman into a thoroughly interested one whose reliability in the maintenance of efficiency advances by leaps and bounds. He becomes an asset worthy of consideration to the steam production department and other departments of production in the works; because we must realize that if steam is not produced efficiently and at the lowest possible cost, it has its economic effect on the goods produced in the works. Given a fully equipped boiler house and a competent fireman, it is not absolutely imperative that the top of chimney should be within the range of vision of the fireman when at the boilers. The fireman should know by the appearance of his fires and the degree of combustion he is obtaining what the condition of his chimney will be. But to reduce the margin of error, or, shall we call it the "Human element," it is safer that the chimney top should be visible from the boiler house, and where it is impossible to have such a direct view, it is advisable to bring the chimney within range by the installation of a mirror or mirrors. If such mirror or mirrors are not used for reading directly the degree of combustion obtained, it is useful for the fireman to check his control by an occasional appeal to the chimney top. Such a practice does not inflict any additional duties upon the fireman, but it certainly ensures a greater margin of safety as far as smoke abatement and high thermal efficiency are concerned. Further, human element efficiency could be catered for by introducing simple but explanatory tables showing the amount of coal wasted due to incomplete combustion. A selection of elementary information that is needed by every fireman is available, and every encouragement for taking full advantage

of all facilities should be given by all employers who have to think in terms of £ s. d., and who have already realized that it is the human element which plays the major part in achieving high boiler house efficiency with a corresponding saving in fuel costs.

The human element of boiler house control if treated as possessing intelligence should be the means of keeping at a minimum visible losses that are liable to occur at any time on any plant. Again the ultimate results of intelligent co-operation of all boiler house human element will most surely bring about the desired effect of eliminating black smoke or even any smoke in such quantity as to be a nuisance, and our towns and cities will glory in an atmosphere free from soot and smoke so far as the industrial chimneys are concerned. Already great strides have been made in some districts in achieving this object, and the relationship which the human element bears to smoke abatement is as much that it is by these efforts clean chimney tops will be the hall mark of their efficiency. Moreover all Local Authorities in industrial centres should provide classes and places of practical instruction where firemen could attend for practical training in the principles of boiler house management and steam production under working conditions. He should understand the proximate analysis of coal, its calorific value, measurements of draught, the analysis of gases, rate of combustion, temperature of feed water, evaporation, steam flow, economizers, superheaters, etc., and everything appertaining to boiler management, certificate should be given for proficiency and local employers could then be assured of securing the right type of skilled man who should be paid at the rate of a skilled fireman and not at the rate of an ordinary labourer.

Many boiler plants in this country have been in existence for a good number of years and make a poor comparison with modern plants equipped with all the latest scientific improvements. The cost of re-building completely would be a considerable expense, and a special tribute is due to the human element responsible for the operation of plants of this description; and it is to their credit that the successful advance which has been made with smoke abatement in these cases is due to their intelligent efforts to get the best out of a difficult position.

Types of Boilers.

Steam boilers of the internally fired description are by far the most common in this country, and unfortunately it frequently happens that they are overloaded, in fact the works

THE HUMAN ELEMENT.

boiler is very often the limiting factor in production, and the fact that increased profits are usually associated with increased production shows the vital importance of keeping a factory running at its full output, and how seriously profits are affected by interruptions and slowing down of processes by inadequate steam pressure, so that while coal must not be wasted by making smoke, the financial aspect of boiler management must be kept in mind.

In reviewing the present day circumstances, it is well to consider the duties and responsibilities of the boiler house human element in two different sections. Dealing first with hand fired boilers and secondly with mechanically fired boilers. Taking into account the circumstances of draught whether it be natural, induced, forced, or balanced draught system in each case. With hand firing the principle of firing small quantities of coal at a time, and firing often, is good service. The fuel bed must be of reasonable thickness to suit the available draught and uniform throughout, special care being paid to the back near the bridge which is liable to burn off more quickly than the front as the flow of air into the furnace for a given damper setting is generally at a nearly constant rate. Firing small quantities of coal and firing often gives a more nearly constant feed of coal to combine with it. The volatile gases of the coal are then given off at a more nearly constant rate. Side firing alternately is a good method and by adopting this practice the flame from the other side of furnace ignites the gases given off the newly fired side more quickly and consequently avoids excessive smoke. The effect of firing heavy quantities of coal with insufficient air to combine with the volatile gases given off is the direct cause of a chimney emitting black smoke. Furnace temperature will be reduced and steam pressure is bound to fall, and an excess of air to the furnace has the effect of cooling down the furnace temperature, so that the importance of regulating the damper and feeding the coal in a proper and systematic manner will be readily understood by the capable fireman.

The Lancashire boiler is the type most commonly used by industrial concerns for steam raising purposes, and fully 75% of the boilers in use are of this type. Care should be taken in installing a boiler to have a good foundation to prevent settling, size of flues, quality of brickwork to prevent leakages, and admission of cold air in the flues and the covering should be non-conductive material. If attention is given to these matters along with many other details, a greater boiler efficiency will result. There is also the Yorkshire boiler similar in design. The water tube boiler by various makers

are very popular for high power stations. Multitubular boilers, vertical boilers of different types and many other types, all of which are recommended by the various makers for steam raising purposes. Care should be taken in selecting a suitable coal for hand fired boilers, and trouble is often caused by getting a coal containing ash of a low fusing point which runs and fills the air spaces of the grate and prevents coal being properly burnt. Fires should not be allowed to burn too low before cleaning out, and where there is a range of boilers, the cleaning out should not be carried out too quickly. The water in the boiler should be kept at a constant level and, where the load varies, feed regulators are a decided advantage. Water should be clean, and if drawn from a river or canal, should be treated. These are just a few of the essential points to watch. It will probably be found that no two plants are exactly alike in every detail, so that each plant must be dealt with under the varying working conditions, therefore it is very necessary that a skilled fireman should be in charge.

Mechanical Stokers.

Mechanical stokers vary in design according to the type of boiler or nature of the work required. Two systems are in general use, i.e., coking and sprinkler stokers. With the coking stoker, coal is fed by gravity from a hopper; the thickness of the fire being regulated by a rack or movable frame. As the coal moves from one end of the grate to the other, complete combustion takes place and the ash is dumped below the grate, so a continuous supply of heat units are being continually liberated, and if care is taken to see the coal is completely burned by regulating the speed of the grate very high furnace efficiency is maintained. On the other hand, careless operating of this type of stoker is likely to waste coal if it is allowed to dump the unburnt fuel.

With sprinkler stokers fuel may be fed by means of mechanical shovels, or by revolving distributors. The fuel is spread evenly over the grate and the thickness is regulated according to the speed at which the coal is fed. The speed depends on the available draught, as there is a limit to which the coal per square foot of grate area can be consumed. If a definite amount of coal is required to be consumed per square foot of grate area, it may be necessary to use mechanical draught, either by installing an induced draught fan or forced draught system of steam jets operating at the boiler front creating a pressure under the grate, or a combination of both forced and induced is sometimes adopted. Mechanical stokers working with natural draughts will burn 35-lbs. of coal per

THE HUMAN ELEMENT.

square foot of fire grate area, and with mechanical draught 40 to 50-lbs. per square foot of grate area. The question of suitable fuel for mechanical stokers calls for the type of stoker being used. With a chain grate stoker and other types of coking stokers, it is possible to burn coal of a very inferior grade having a low calorific value like 9,000 to 11,000 B.T.U.s. Usually slack coal is used for stoker work, and in some instances it required to be graded to suit the type of stoker.

With sprinkler stokers washed peas or beans having a calorific value from 12,000 to 13,500 B.T.U.s are most suitable, because ungraded fuel has the tendency to cause a jam in the distributing hopper and cause a stoppage of the firing operations.

Stoker grates are made either to move mechanically or remain fixed. Usually with fixed grates a means of rocking the fire bars periodically with a hand lever is used. This keeps the fire open by breaking up the clinker on the bars, and at cleaning times when the operation is the same as with hand fired boilers it enables the clinker to be lifted and disposed of more quickly. Since the fire door of mechanical stokers is not required to be opened except at cleaning times (with fixed grates) the amount of excess air to the furnace is limited and a continuous high furnace temperature is maintained; with a properly regulated draught, the danger of emitting black smoke is almost entirely overcome.

Economizers are a great advantage placed behind the boilers in the main flue so the feed of water to the boiler can be heated by the waste gases before passing up the chimney.

Superheaters are installed in line with the passage of the flue gases from the furnace in the Lancashire boiler in line and at the back end of the flue tubes. Saturated steam from the boiler passes through a series of tubes and the temperature is raised to a much higher degree without alteration to pressure. The heat absorbed by the steam is a direct saving in heat units, and there is a fall in the flue gas temperature after passing through the superheater.

Superheated or dry steam is a great advantage in some works where temperature is more important than pressure.

Evaporation. By using a water meter, or a steam meter which will measure the total supply of steam actually made and weigh the correct amount of coal used over a given time, we have two figures, i.e., coal and steam. For each lb. of coal burned we get a definite quantity of steam, the amount varying considerably according to the amount of heat actually absorbed in the steam—so that $\frac{\text{steam lbs.}}{\text{coal lbs.}} = \text{evaporation per lb.}$

of coal. So much depends upon evaporation, and it is the object of each boiler house staff to get as high an evaporation figure as possible. Actually the coal which is fed into the furnace is spoken of as being equal to so many heat units, as the liberated heat units pass from the furnace to the chimney and heat is absorbed by the boiler heating surface, super-heaters, economizers, air pre-heaters, and finally that which passes to the chimney is lost and is a percentage of the total heat in the coal. It will be seen that to get good evaporation results, it is absolutely essential to have clean heating surface, no air leaks, a properly regulated supply of feed water to the boiler, and a sufficient draught.

I have specially avoided mentioning any particular make of stoker. There are such a number of varying types and designs available to suit all conditions of service that we must realize that the engineer has made an honest attempt to cut out the "human element" in its primary operation.

It is very astonishing that the adoption of mechanical methods of firing for steam production has received such a small amount of support. On large plants where large quantities of steam are produced, considerable use has been made of the mechanical stoker, and great efficiencies and economies have been effected, but when we come to the small steam user with only one or two boilers, it is very rarely that we find the mechanical stoker. In making this statement, I am speaking from my personal experience over many years in the City of Manchester. Why this should be so is somewhat of a mystery to myself and my colleagues. I can hardly think that the fact that mechanical stokers do not entirely eliminate, as the pioneer engineer thought it would, the human element that makes the small steam user so reluctant to venture into the sphere of mechanism, but the fact remains that its adoption on the small boiler plant is very rare indeed.

The mechanical stoker calls for a highly skilled and efficient attendant if real value is to be obtained from its installation. Probably a more technically equipped man is required, for I have known cases where a mechanical stoker in the hands of an incapable man was by far a more consistent smoke producer than any hand stoker could ever hope to be, but if the right man is in charge, it is just the other extreme. If there are any here directly interested in steam production, I would ask you to go carefully into the matter of adopting mechanical methods—great possibilities are in front of the mechanical stokers, and I can assure you that it is by this means that further increase in efficiency and economy can be obtained; and to those of you who are steam producers, I

THE HUMAN ELEMENT.

would say that it is your duty to look for high efficiencies, and if you do your duty well and concentrate upon that object, you will also help me and other Smoke Inspectors in the performance of our duty. By obtaining these high thermal efficiencies, you will cut out wastage and you will not require the attention of the Smoke Inspector, and you will be doing your duty to your fellow-man by helping to keep a pure atmosphere.

I have throughout this paper advocated, as most essential, whether hand or mechanical methods are used to supply fuel to the furnace, that the man in charge of the operations shall be fully competent and efficient, but to obtain this type of fireman is by no means an easy task at the present time. Where hand firing methods are used, the work will not in itself attract the type of man that is required, and certainly the remuneration is no inducement. We have got to realize that if we want the man to be what we know he ought to be, the conditions will have to be vastly different to those generally obtained in the majority of boiler houses to-day, and also to get the more intelligent man into the boiler house we shall have to pay him. There should be no grudge about pay—it is a scientific job burning coal, and a good fireman in the boiler house will save in fuel many times more than is required to pay him above the standard rate in pay demanded by the man whose only qualification is that he can shovel fuel into a furnace.

The Sanitary Inspector.

We are living to-day in an age which demands a thoroughly equipped and efficient Public Health service, and in that service it is the privilege of the Sanitary Inspector to play a very important part. In the early days a Sanitary Inspector was probably a good workman in some of the building trades, and many of them did excellent work and were the pioneers in many of the great sanitary reforms which the general public is enjoying to-day. At present, the Sanitary Inspector has to pass a statutory examination held by the Royal Sanitary Institute and the Sanitary Inspectors' Association's Board or some University, and is expected to have had a thoroughly good education, or to have matriculated or taken one of the Oxford or Cambridge local examinations, and consequently this educational advantage greatly assists him in carrying out his work with much more efficiency than in the old days. The Sanitary Inspector is an essential unit in the Public Health service of the country, and he plays an important part in co-operating and assisting the Medical Officer of Health in the control and prevention of infectious disease; they have to

administer the law relating to drainage, water supply, food and drugs, dairies and cowsheds, meat food preparation, workshops, over-crowding, ice cream, rats and mice, smoke and many other regulations. Their duties have gradually multiplied and to-day they have innumerable Acts of Parliament, Orders and Regulations to administer; the work is responsible, extensive and varied, and by continual study and a desire for knowledge the Sanitary Inspectors are not only keeping abreast of the progressive age, but are becoming more and more the technical advisors on all matters affecting the welfare and health of the community. There is no body of officials in the Local Government service who are more enthusiastic in their work, and stand second to none for efficiency. But however capable he may be, it is a physical impossibility for the district Sanitary Inspector to carry out the duties of Smoke Inspector with success, owing to having to carry out his other duties which are almost innumerable. He cannot devote sufficient time to take observations and make the necessary examinations and enquiries afterwards; he must devote the whole of his time to the work if it has to be a success, if there are a sufficient number of works in the area. In some districts, the Inspector is handicapped by strong influence both in the Council Chamber and outside amongst certain sections of the public against any action being taken for smoke nuisance offences which some consider is a necessary evil in all industrial areas, and others for private reasons. We have also to regret the fact that in some instances Local Magistrates are not very sympathetic when cases of this kind are brought before them, and they either dismiss the case, or only inflict a very nominal penalty which is no deterrent to other possible offenders, nor does it give any incentive to the Inspector to trouble with any further cases. Here again we have the "human element" in direct opposition to a worthy cause, and inimical to the health of the community by whom they have been elected to serve and protect. Again we have the position that in one district action is being taken, whilst in the adjoining district, no effort is taken to deal with the nuisance; there is an utter lack of uniformity as between one district and another with regard to inspection, duration of emissions, concessions allowed, and qualifications of Inspector, etc. Taking these anomalies and difficulties into consideration and realizing that smoke knows no boundaries, I am confident that not only from a Sanitary Inspector's point of view, but for the benefit of the community, and knowing it to be impossible for each Local Authority to appoint its own Smoke Inspector, the only possible and practical solution of this important question is the

THE HUMAN ELEMENT.

forming of Regional Committees provided for in the Act and again recommended in Circular No. 759 by the Ministry of Health, both for advisory and statutory purposes. These Committees could be divided into district Committees and each would be representative of the whole of the Local Authorities within the group. They would have the whole time qualified Inspectors and would have statutory powers and would take proceedings for smoke offences. By forming of Regional Committees it would not prevent the Local Authority from taking action in their own districts, but would give better supervision and uniformity of action and abolish parochial influence. It is only by these combined efforts that progress will be made and the control of local affairs to be controlled by the appointed representatives of Local Authorities. We all admit something must be done, then let us commence with intensive propaganda pointing out the evils of smoke, and by co-ordinating and co-operating all our forces—the Scientist and the Engineers, Medical men and Manufacturers, Councillors, Sanitary Inspectors and the whole “human element,” we shall then, in a very short time, see the realization of our ideals and ambitions, a clear sky and a pure atmosphere which is the birthright of all.

DISCUSSION.

MR. C. RAIMES (Newcastle-upon-Tyne) said that he felt sure that they had all listened with very great interest to the interesting, instructive, and thoroughly practical paper given by their friend Mr. Crossley. The human element could not be ignored. A thoroughly capable stoker, one who understood his work and took an interest in it, was a very valuable asset to his employer, and a most important factor in smoke prevention. Given sufficient boiler power, good fuel, and other necessary conditions, a good stoker would keep the necessary head of steam, save coal, and above all, practically eliminate black smoke. The importance of the human element could not be over-estimated. Again, in the case of mechanical stoking, if the fireman did not know his work, if he was not a capable man, he would render ineffective the best and most efficient smoke-preventing apparatus on the market.

Great attention had been given within the last few years to the education of firemen, and this was all to the good, classes being conducted by gentlemen of very great ability in the engineering profession in many of our towns and cities. They had one held in their local Technical College, which was commenced two years ago, with

an average attendance of 50. From careful observations which were constantly being made in the city, the results had been most apparent. Already there was a very great diminution, both in the colour and density of the smoke given off by their factory chimneys. There again was a concrete example of the human element.

Many of the audience might have noticed during their brief sojourn in the city the clear and bright atmosphere that was present. There we had the human element, men who had profited by the knowledge received at the classes, which was supplemented by practical advice given by their District Inspectors when visiting the various works. While the education given at the classes was to be highly commended, it was felt that a greater number of practical lessons might be given. It was suggested that firms might with advantage adopt a system of training for stokers, a sort of apprenticeship whereby a youth could enter the boiler room, say for two years, in order to receive practical training. A competent fireman was a skilled man; he ought to be adequately paid and work under congenial conditions. The question of the boiler-house or stoke-hole did not always receive the attention that it deserved; how often did they find them dark, dirty, and placed in any odd corner of the works? That should not be; it was not conducive either to the health of the worker or the efficiency of the work. They had in the city a famous toffee manufactory which was about the last word in hygienic conditions. Steam was raised by a large Lancashire boiler carrying a constant head of 120 lbs. of steam. The principals, realizing the importance of cleanliness, light, and air in all departments of their works, had an ideal boiler-house. The interior walls were painted and it was adequately lighted and ventilated. The stoker was clean, as befits the surroundings, and here was his claim for the human element, during the 20 years it had been established, never once (and repeated observations were taken) had it been necessary to communicate with the firm about the emission of black smoke, for the simple reason that black smoke was never given off from the chimney.

MR. L. H. DIBBLIN (Willesden) complimented Mr. Crossley on his paper, especially on that portion where due regard should be given to the human factor—the man who did the actual work, particularly in hand firing—who so often was not deemed worthy of consideration yet whose efforts made so much difference as to whether the plant was being run wastefully or economically. He disagreed with the previous speaker (Mr. Raimes, Newcastle), that hand firing was the best method. Each method had its advantages; an intelligent stoker on hand firing was excellent, but with large plants mechanical stokers were imperative, and required intelligent operation.

The greatest bugbear whether on large or small plants was the inadequacy of the plant to deal with its load—sometimes even a normal load, but more frequently with a fluctuating load—when in

THE HUMAN ELEMENT.

order to cope with the peak, "pushing" was resorted to. He had one grievance with Mr. Crossley in that in his paper he had not made reference to what had become in many districts an intolerable nuisance, viz.: the emission of grit from the use of pulverized fuel. Such emissions were a menace to public health and had added to the worries of Local Authorities' Officers. He was aware of the various processes installed throughout the country to deal with this nuisance; the principle methods used being cyclonic or centrifugal arrestors, flue gas washing (such as the Modave) and electrical precipitation (such as the Lodge-Cottrell). For each method it was claimed and probably gave a 70%, 80% or 90% efficiency. It was, however, with the *X%* of grit *not* collected but which escaped from the chimney with which he (the speaker) was concerned, as it was that *X%* which caused the nuisance and as the law now stood it seemed doubtful if a Local Authority could sustain any action for this nuisance, particularly against a statutory undertaking.

Although by Clause 3, Section 1 of the Public Health (Smoke Abatement) Act 1926, it was a defence to show that the "best practicable means" had been taken, the onus was in reality thrown back on the Local Authority who would have to prove that "the best practicable means" had *not* been taken.

Before embarking on expensive litigation it behoved them all to read well the summing up of Lord Dunedin in the *Manchester v. Farnworth* case 1930, A.C. page 183, substituting the word "grit" for "Sulphurous fumes" they would then appreciate the difficulties confronting Local Authorities.

He would be grateful to hear the experience of other delegates on the use of these different methods, and to what extent such apparatus had been successful in abating this nuisance from grit.

MR. R. BULMER (Consett Iron Co., Ltd.) wished to thank Mr. Crossley for his excellent paper, especially because of its practical and comprehensive nature. He thought they would all agree that it was necessary that the actual stoker of a boiler or boilers should be instructed in at least the elements of combustion, especially in so far as it was related to smoke abatement. He did not agree with a former speaker who stated that the stokers in Newcastle were well versed in the art of stoking. Though this might be true of one or two, he had found several cases of neglectful stoking in the smaller industrial plants of the city.

Mr. Crossley had quite rightly stressed the necessity of instruction regarding the chemical analysis of coal, and especially the proximate analysis. He would point out that, whilst this was important, it was necessary to note that the proximate analysis of coal was not by any means a criterion by which coal might be selected for boiler purposes. Such analysis might be quite misleading. The question of analysis of coal naturally led to the selection

THE HUMAN ELEMENT.

of suitable coal for steam raising, and to the question: What was a suitable coal? One's experience had shown that often coals of a most unpromising "proximate" composition were excellent boiler fuels, maybe because of some happy proportion of say hydrogen and oxygen ratio. Frequently, also, coals of high calorific value (the usual standard by which coals are bought) were inferior in effect as steam raisers, to other coals whose more obscure virtues were nevertheless real and effective. Selection of coal suitable for boilers was, therefore, not always a simple process.

Mr. Crossley pointed out that 75% of the industrial boilers in this country were of the internally fired type, in which the Lancashire boiler was predominant. Mr. Bulmer thought that one could safely say that raw coal was a most unsuitable fuel for internally fired boilers. The reason for this would be appreciated when one remembered that the volatile matter of the coal, escaping from the fire as tar, water vapour, and hydrocarbon gas, was immediately brought into contact with the relatively cool surface of the boiler shell, whereby the hydrocarbons were condensed, or deposited, or at best carried forward at a temperature too low to allow of their ultimate combustion. Thus a large proportion of the original calorific value of the coal was lost, and smoke was produced.

This brought them to a consideration of what were called the Gross and Nett calorific values of coal. The former was the value usually quoted, whereas the latter was that value which was obtained under best conditions in the boiler. The difference between the two values varied with the hydrogen content of the coal and was usually between 400 and 600 B.T.U.'s per lb. coal (i.e., 4% of the value). Thus, from the point of view of the boiler efficiency, coal started unfavourably handicapped. Thus Mr. Crossley's paper was linked in this respect with Mr. Mott's paper of yesterday and they might therefore mention the use of coke in steam boilers. Coke of the right size, properly graded and carefully manufactured was a fuel which should be more seriously considered to replace coal as a boiler fuel. Coke was smokeless, contained little hydrogen (thus its gross and nett calorific value were almost identical), it produced no hydrocarbons which were difficult to burn, and which covered the boiler heating surface with soot. The proportion of radiant heat from a coke fire was very high, so that the heat transfer efficiency was high especially in internally fired boilers.

Finally, he wished to say that they have frequently proved, in the course of their investigations, that Lancashire boilers fired with coke nuts would produce the same quality of steam with a saving of 25 to 30% of fuel, over the same load conditions as when good average coal was used. To put this another way, the steam producer could afford to pay up to 30% more for coke than coal, obtaining at

THE HUMAN ELEMENT.

least as good results, and in addition being guilty of no smoke emission whatever.

MR. E. B. HOCKEN (Nottingham) asked to what extent were local authorities carrying out smoke abatement work? It would be interesting to know how many industrial towns employed special smoke inspectors. He mentioned the nuisance from electric power stations due to the fluctuating loads, and asked what were the best means to combat it. He could corroborate Mr. Crossley's statement that the human element reached as far as the directors, having experienced it repeatedly. The periodic overloading of boilers just for a small portion of the day was a further point, and the only solution so far as he could see was the installation of a steam accumulator. He could not agree that mechanical stokers were a guarantee of smoke prevention; where the loads fluctuated rapidly they did not appear to be a success. He mentioned and described electrical precipitation of grit from pulverized fuel, which was already installed at Willesden.

MR. JAMES LAW (Sheffield, Rotherham, and District Smoke Abatement Committee) stated that Mr. Crossley's paper had left them very little for criticism. He would like to state that anyone who advocated hand-firing in preference to mechanical stoking had not studied their subject to any considerable extent. The fundamental law of combustion was the uniform supply and control of air and fuel to the furnace. To burn 1-lb. of fuel about 20 pounds of air were required per pound of fuel used. The only method of achieving this with any degree of constancy was by mechanical means and the minimizing of the human element. Even when this was done there was no guarantee that conditions would be good. The blame for smoke was always put on the fireman, but from his own experience the difficulty more often rested with the engineer, the works manager or the manufacturer himself. If conditions were to be good, there must be co-operation between these people, and the manufacturer must do his share as well as the works manager, engineer or fireman. In dealing with grit deposit, Mr. Dibblin (Willesden) had asked for information. There were three ways of preventing grit emission from a chimney—namely, baffling, cycloning and washing, and the electrolytic precipitation method. Baffling only held back a proportion of the grit, cycloning and washing was not possible on account of limited water supply, and at present he stated that the precipitation method was being tried. If this was not proving a success it was due to some imperfection in the plant, and this difficulty would doubtless be overcome with further experiment. If conditions were as bad as Mr. Dibblin stated the Local Authority undoubtedly had a case to fight, and prosecution should follow, even if the case had to be taken to the House of Lords for decision.

THE HUMAN ELEMENT.

MR. J. W. BEAUMONT (Halifax) pointed out that the West Riding Regional Smoke Abatement Committee, which was an Advisory Committee, had two years ago established such classes within their area. A particular feature of the scheme established was that they had obtained uniformity in instruction by co-operating with the various education authorities in drawing up a syllabus which was followed at all training centres. Examinations were held annually and successful candidates were granted a certificate issued by the Regional Committee. It was hoped that this Examination Scheme would be the forerunner of a much greater scheme established on a national basis. Meanwhile, other Regional Committees were urged to establish similar schemes within their own areas.

LIST OF PUBLICATIONS OF THE NATIONAL SMOKE ABATEMENT SOCIETY.

(All prices include postage).

1. **The Smoke Abatement Handbook.**—A newly-published reference book containing concise authoritative articles on the principal aspects of the subject, numerous statistics and a wide variety of useful information. A vademecum for those who write or speak on the subject. 8vo. pp. 48. 6d. 5/- per doz. copies.
2. **Home Fires Without Smoke.**—Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. 2/- and 3/6 (cloth).
3. **Report of the 1924 Smoke Abatement Conference.**—Only a few copies left of a valuable Report. 4to. pp. 308. 5/-.
4. **Report of the 1926 Smoke Abatement Conference.** 4to. pp. 98. 1/-.
5. **Smoke Abatement in Salt Lake City, Utah.**—A full report of the intensive and successful campaign in Salt Lake City. 8vo. pp. 43. 3d.
6. **Smoke and Health.**—By Dr. J. S. Taylor, M.D., D.P.H., Assistant Medical Officer of Health, Manchester. 8vo. pp. 12. 2d.
7. **The Progress of the Electrical Grid.**—A paper read at the Liverpool Conference, 1931, by Robert Blackmore, M.I.E.E. 4to. 3d.
8. **The Production and Use of the New Smokeless Fuel "Dryco" in Liverpool.**—A paper read at the Liverpool Conference, 1931, by Ralph E. Gibson, M.Inst.C.E., M.Inst.Gas.E. 4to. 3d.
9. **Atmospheric Pollution as Affecting Visibility and Visibility as Affecting Aviation.**—Papers read at the Leicester Conference, 1930, by M. G. Bennett, M.Sc., and F. Entwistle, B.Sc., of the Meteorological Office, Air Ministry. 4to. 3d.
10. **Reprints From the Papers Read at the 1924 Conference.**
"The Complete Gasification of Coal." T. R. Wollaston, M.I.Mech.E.
"The Fuel of the Future," Sir Francis Goodenough.

"Powdered Fuel and the Smoke Problem." J. T. Dunn,
D.Sc., F.I.C.

"How Electricity Can Help in Abating Smoke." Julius
Frith, M.Sc., M.I.E.E.

"Power from Sources other than Coal." Prof. Miles
Walker, M.A., D.Sc.

"Furnace and Tank Boiler Design." W. H. Casmey.

"The Smoke Inspector and the Cost of Production." H.
G. Clinch, M.R.San.I., M.I.H.

Price, 3d. each.

11. **The Influence of Air Pollution Upon Vegetation.**—By
W. W. Pettigrew, V.M.H. 8vo. pp. 8. 6d.

12. **Clean Air for Leeds.**—(Published Leeds Tercentenary
Committee). pp. 52. 3d.

13. **Smoke Abatement and Fuel Economy in Steam Boiler
Practice.**—(Published Manchester and District Regional
Smoke Abatement Committee). 8vo. pp. 11. 1d.

14 and 15. **The Open Fire, and The Black Smoke Tax.**—
Pamphlets published by the Manchester Air Pollution
Advisory Board. 8vo. Gratis, by post, 1d.

16. **N.S.A.S. Annual Reports.**—Gratis, by post, 1d.

17. **Smoke and Fumes Nuisances from Road Vehicles.**—A
Report of the Meeting held on June 3rd, 1932, by Dr. J.
S. Owens, A.M.Inst.C.E., M.I.Mech.E. and R. P.
Mahaffy, M.A. 3d.

18. **The Journal of the National Smoke Abatement Society.**—
A Quarterly Journal devoted to smoke prevention. It is
indispensable to all who are working upon or interested
in, the problems of smoke abatement and atmospheric
pollution. With the co-operation of leading authorities
it deals with industrial and domestic problems; technical
methods; news from local authorities and Regional
Committees; reports of conferences, inquiries, etc., and
keeps the reader up-to-date in every aspect of the problem.
Per annum (4 issues), 2/6. Post free. To members:
GRATIS.

"Fumifugium."

It is hoped that it will be possible to publish, within a few
months, a reprint of John Evelyn's famous pamphlet on
smoke Abatement—"Fumifugium" (1661).

NATIONAL SMOKE ABATEMENT SOCIETY

President : H. A. DES VOEUX, M.D.

Chairman and Hon. Treasurer : ALDERMAN WILL MELLAND, M.A., J.P.

Hon. Advisory Secretary : Sir LAWRENCE W. CHUBB.

General Secretary and Editor : ARNOLD MARSH, M.Sc. Tech., M.Inst.F.

Vice Presidents :

H.R.H. THE PRINCESS LOUISE, DUCHESS OF ARGYLL.

THE RIGHT HON. THE EARL OF STAMFORD.

THE RT. REV. THE LORD BISHOP OF LONDON, P.C.,
K.C.V.O., D.D.

THE RIGHT HON. LORD NEWTON, P.C.

THE VERY REV. THE DEAN OF CANTERBURY.

THE VERY REV. THE DEAN OF WELLS.

SIR THOMAS BARLOW, Bart., K.C.V.O., F.R.S.

SIR OLIVER LODGE, F.R.S., D.Sc.

SIR NAPIER SHAW, Sc.D., F.R.S.

Sir ERNEST SIMON.

PROFESSOR J. B. COHEN, Ph.D., D.Sc., LL.D., F.R.S.
PETER FYFE.

JOHN W. GRAHAM, D.Litt., M.A.

COUN. W. E. HINCKS, J.P.

DR. J. JOHNSTONE JERVIS, M.D., D.P.H.

COUN. W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.

FOURTH ANNUAL CONFERENCE TO BE HELD AT NEWCASTLE UPON TYNE *September 23rd, 24th, 25th,* 1932

PROGRAMME

PROGRAMME



FRIDAY, September 23rd.—

8 p.m. RECEPTION by the Lord Mayor of Newcastle upon Tyne (Councillor J. G. Nixon, J.P.) at the Laing Art Gallery. The PRESIDENTIAL ADDRESS will be made during the course of the evening. Invitations will be sent to those intimating their intention of being present at the Conference (*see accompanying reply form*).

SATURDAY, September 24th,

9-30 a.m. In the Meeting Room, the Royal Station Hotel.

ANNUAL GENERAL MEETING

Chairman: The President.

AGENDA.

1. To approve the Minutes of the previous Meeting.
2. To receive the Annual Report.
3. To receive the Annual Statement of Accounts.
4. Election of President.
Vice-Presidents.
Hon. Treasurer.
Council.
Executive Committee.
5. Any further business.

10-30 a.m. CONFERENCE. FIRST SESSION.

Chairman: Dr. J. T. DUNN, J.P., F.I.C.

“The Domestic Smoke Problem: The Possibilities of
Coke Oven Fuel”

By R. A. Mott, M.Sc., F.I.C., of the Department of Fuel
Technology, the University of Sheffield.

12-15 p.m. Depart from Hotel by motor-bus on visit to the Roman Wall at
Borcovicus. Lunch will be taken at Chollerford, and the return
journey via Hexham. (By invitation of the Newcastle Corpora-
tion).

8 p.m. At the Royal Station Hotel: Informal Meeting and Discussion.

SUNDAY, September 25th—

10 a.m. In the Meeting Room, Royal Station Hotel

CONFERENCE: SECOND SESSION.

Chairman: Sir THOMAS OLIVER, M.A., M.D., D.Sc., D.L., J.P., etc.

“The Psychological Effects of Smoke,”

By Alderman David Adams, J.P., Chairman, Newcastle Public Health Committee.

11-30 a.m. “The Human Element in Smoke Abatement.”

by A. E Crossley, Chief Smoke Inspector, Manchester.

(This paper will deal with the Stoker and the work of the Smoke Inspector).

2-30 p.m. The Corporation will provide buses to take delegates a tour to the coast if a sufficient number wish to avail themselves of the invitation.

The Proceedings of the Conference, containing the papers read, the discussions, names of those attending, etc., will be published in due course, and will be sent, gratis, to all from whom the Conference Fee of 10/6 has been received.

Delegates taking part in the discussions (including the Informal Meeting on the Saturday evening) are requested to hand a copy of their remarks to the Secretary at the time, or to forward them to him as soon as possible afterwards.

CONFERENCE ARRANGEMENTS.



- Hotel.** The Conference Headquarters will be the ROYAL STATION HOTEL, Newcastle upon Tyne. Members and delegates in reserving their rooms should mention that they are attending the Conference in order that they may obtain the special terms which have been arranged.
- These are:
- Dinner, Friday evening to Breakfast, Monday morning,
including baths £2/17/6
- Bed, bath, breakfast, luncheon, and dinner, per day - £1/1/-
- Reception.** Those desiring to receive an invitation to the Lord Mayor's Reception on the Friday evening should indicate this on the reply-form, which should be returned as soon as possible.
- Visit to the Roman Wall.** It is hoped that all attending the Conference will participate in this exceptionally interesting visit. Kindly indicate your intention on the accompanying reply-form.
- Motor Excursion, Sunday.** The Newcastle Corporation have kindly offered to convey members by motor-bus to the sea-coast on Sunday afternoon, provided that a sufficient number wish to participate in the excursion. See the reply form.
- Meeting Place.** All meetings will be held in the Meeting Room in the Royal Station Hotel, with the exception of the Reception on Friday evening at the Laing Art Gallery.
- Newcastle Official Guide** Copies of the Official Guide to Newcastle upon Tyne will be available on request at the Conference Office, the Royal Station Hotel.
- Conference Fee.** By general request a Conference Fee of 10/6 per member or delegate will be made this year. This will enable a full Report of the Proceedings to be prepared, and will defray some of the Conference expenses. A copy of the Proceedings will be forwarded to all attending the Conference.
- Date for Reply.** The Secretary will be obliged if those intending to be present would return the accompanying reply-form as soon as possible, and in any case **not later than September 19th.**
- Further Information** Any further information may be obtained upon request from the Secretary, National Smoke Abatement Society, 23 King Street, Manchester up to September 22nd., and afterwards at the Conference Office, Smoke Abatement Conference, Royal Station Hotel, Newcastle upon Tyne.

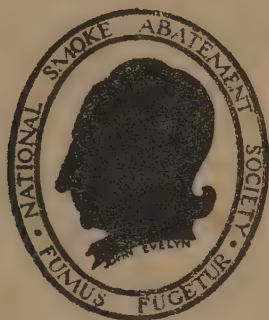
23 KING STREET,
MANCHESTER.

phone }
Tele } BLAckfriars 0896.
grams }

ARNOLD MARSH
General Secretary,

e31

National Smoke Abatement Society



PROCEEDINGS *of the* Sheffield Conference 1933

Price
One Shilling.

23 KING STREET
MANCHESTER 2

PROCEEDINGS
of the
 Fifth Annual Conference
of the
 NATIONAL SMOKE
 ABATEMENT SOCIETY
 HELD AT
 Sheffield
 September 22nd, 23rd and 24th
 1933



CONTENTS:

Presidential Address by Dr. H. A. Des Vœux	3
Conference Resolutions... .. .	15
The Five Years Clause and Other Matters arising from the Public Health (Smoke Abatement) Act, 1926, by Councillor W. Asbury. J.P.... .. .	17
Discussion on Councillor Asbury's Paper	24
How the Citizen takes the Air: the Personal Significance of the Coal Smoke Problem by Mrs. Millicent Jast ...	32
The Combating of Domestic Smoke in Industrial Areas by R. H. Clayton, M.Sc., M. Inst. Gas E., and Charles Gandy... .. .	45
Joint Discussion on the Foregoing Papers... .. .	54

PRESIDENTIAL ADDRESS

By Dr. H. A. DES VOEUX.

The past century has seen remarkable advances in the agencies of production. Goods are produced to-day of a quality and character and in a profusion not dreamt of a hundred years ago. These developments are due to the extraordinary progress which has been made during that period in scientific discovery—including in that expression both the results obtained by the pure scientist and those which are attained by the applied scientist. We are face to face with a situation in which worldwide depression is brought about, we are told, by the very capacity of productive agencies, a capacity which has outrun the means of distribution or at any rate of consumption. This transformation in the industrial sphere has created gradually, almost imperceptibly, social and economic problems of overwhelming difficulty, for instance hideous towns and insanitary overcrowding, which are at long last disturbing the conscience of the whole country, and have to be remedied at enormous cost instead of having been grappled with as they arose. The pure scientist never seemed to envisage the state of affairs which would arise as the result of his labours, but is now making a full contribution to the solution of one of the problems which has arisen during this century to befoul our towns and deteriorate the health of town dwellers—the Smoke evil.

1933.

It would be interesting to canvass all those who are now interested in the Abatement of Smoke and to analyse their answers to the question, "Why did you become a Smoke Abater?" I think that the greater number would answer "Dirt and Gloom." All were aware that the greater part of this condition was due to the combustion of coal, but few thought of atmospheric dirt except as consisting of smuts, small black sticky particles with a disagreeable smell reminiscent of sulphur fumes, adhering to everything including persons and their clothes, soiling collars and furniture. Knowledge was quite vague and not a subject of interest. The first attempts to obtain some accurate knowledge concerning the impurities of city air were made by individuals. They were isolated and sporadic, methods were employed according to the ideas of the

PRESIDENTIAL ADDRESS.

individual and results were divergent or difficult to compare. Shaw and Owens in their book "The Smoke problem of the Great cities" refer to the experiment conducted by Russell in 1885, the results of which were published in the monthly Weather Report of the Meteorological Office in which air was filtered at a rate of 250 c.ft. per hour through glass wool; to the experiment by Professor J. B. Cohen in 1897 in which air was filtered at the rate of 25-35 c.ft. a day through a weighed cotton wool plug; to the determination made in Manchester by Mr. W. Irwin in 1902 by estimating the quantity of impurity contained in snow after it had been exposed for 10 days. The need was great for some organized study of the whole question and in 1910 Dr. Owens and I stepped in the breach, and began to think out methods calculated to give results which would command general acceptance and afford a basis for comparing one area with another, and for deciding as regards a particular area whether things were changing for the better or the worse. We agreed that the first instalment of knowledge that was required was the amount of dirt which fell from the air and its composition. Hence Dr. Owens' original invention in this line—the Standard Gauge into which the dirt falls by gravitation and is either washed by rain or artificially into a bottle, and as most of you know this method has with slight modification stood the test of time. Fortunately we were to engage the sympathy of the Editor of *The Lancet* and his analyst—the late Mr. Vasey, to whom the bottles were sent for analysis once a month. It was Mr. Vasey who devised the methods of examination, and the standard which he set was a high and complete one and has since only been modified in detail.

The Beginnings of the Investigation.

At an Exhibition organized in London by the Smoke Abatement Society in 1912, a Committee was formed for the Investigation of Atmospheric Pollution, and was providentially able to enlist the services of Sir Napier Shaw, F.R.S., as its first Chairman. It was an unofficial body, depending on the voluntary services of eager workers, but its activities were conducted under considerable financial handicap. Nevertheless it accomplished a considerable amount of work, for it laid down methods which have stood the test of time. It was also successful in securing the help of a number of local authorities who undertook to initiate systematic observations by the methods recommended. In due course, the Committee was accorded official recognition, for in 1917 a grant towards the expenses was secured from the newly formed Department

of Scientific and Industrial Research, and the Committee, as part of the arrangements for the grant, became an Advisory Committee on Atmospheric Pollution to the Meteorological Office. In 1927 a further change took place. As from 1st April in that year, the Department of Scientific and Industrial Research undertook, for a period of 3 years in the first instance, the responsibility of organizing the central services required in connection with the work on condition that the co-operating authorities contributed not less than £500 per annum towards the cost. The Department further promised financial assistance amounting to half the annual cost of the central services up to a maximum of £500 annually. The organization for the investigation of atmospheric pollution as it exists to-day thus came into being. It may not be out of place to devote a few minutes to describing the general character of the organization thus established under the auspices of the Department. Basically the scheme, as it always did, rests upon voluntary work and upon local and other co-operating authorities who undertake to carry out in their respective areas, continuous observations of the amount and nature of the pollution.

This fact should not be overlooked. The investigation is not a Government venture—it is essentially a venture on the part of local authorities who having an enlightened view of their statutory responsibilities in the matter of smoke abatement, decide to co-operate in procuring scientific data concerning the amount and nature of the impurities in the air, as a step towards remedial measures. Naturally, however, the mere fact of their co-operation makes it desirable that there should be some central clearing house responsible for arranging that the determinations at different centres are made by standard methods the results of which are capable of comparison; for advising when necessary on such matters as choice of sites for the observations; for keeping the standard methods under review; and, as and when the need arises, for developing new methods. The central clearing house is also needed to arrange for the collection of the results obtained at the local centres, and for their correlation and discussion in annual reports. Without such central services much of the value of the work done by the individual authorities would be lost, and it is as a central clearing house that the Government Department of Scientific and Industrial Research is now acting. For the purpose of advising it in the discharge of these responsibilities the Department has appointed a Committee of scientific experts (the Atmospheric Pollution Research Committee) whose Chairman is Dr. Simpson, Chief of the Meteorological

PRESIDENTIAL ADDRESS.

Office; and it has also appointed a Superintendent of Observations (Dr. J. S. Owens) whose advice is at the disposal of those taking local measurements. In addition, the scheme includes special arrangements for promoting the closest possible contact between the Department and its Research Committee, and the co-operating authorities. To this end a Standing Conference of Co-operating Bodies has been set up, to which all who are taking part in the work, whether by maintaining observations, or by contributing to the cost of central services, are entitled to send representatives. The Conference is an autonomous body appointing its own Chairman and making its own Standing Orders. Its meetings, which take place twice annually, provide opportunities for the discussion of problems of general interest in connection with the measurement of atmospheric pollution and for informing the Department of problems or difficulties arising in connection with the work, or, alternatively, for advising the Department as to matters needing attention.

The present organization appears to be functioning very effectively. During the year ended 31st March last there were associated with it as many as 79 bodies (for the most part local authorities) who between them contributed £771 towards the cost of the central services and maintained in all 86 deposit gauges, 10 automatic filters and 10 sets of apparatus for determining the concentration of sulphur gases in the air. These figures do not take cognizance of the Government's assistance for the Government not only assists financially but co-operates by maintaining observations. The success of the scheme has during the past twelve months been formally recognized by the Department. As indicated already, the Department undertook its present responsibilities for 3 years only in the first instance. At the end of that period the undertaking was repeated for another 3 years. Last autumn, the whole position was further reviewed by the Department when it decided that subject to the financial conditions previously laid down, the work should be continued indefinitely as a normal part of its activities. This result cannot fail to be gratifying to those of us who well remember the struggles of the early days and is ample reward for the energy and enthusiasm then put into the work. It is a matter of satisfaction too, that despite the changes which, from time to time, have taken place in the general arrangements for the conduct of the work since it was first started, continuity has not been sacrificed, and we have now a valuable series of Annual Reports which have appeared in unbroken sequence from 1914-15 onwards.

The Activities of the Committee.

It is to be observed that the objects of the scheme are scientific. Its business is solely concerned with the collection of reliable scientific facts concerning the amount and nature of the pollution in the air for use in combatting the smoke evil. For this purpose the standard methods used are kept under continuous review, new methods developed as and when the need arises, and other incidental investigations are pursued connected with the general problem. The existence of an effective central scientific committee is particularly important for these purposes. I have had the opportunity, particularly in recent years, of being closely associated with the work of the Research Committee, and while this is not the occasion for giving a full account of it, I propose to take advantage of the occasion to refer briefly to some of the work carried out by it under the above headings in recent years.

(1) The examination of existing methods.

- (a) *The Deposit Gauge*: You will be aware that the instrument which is most generally used for the observations is the deposit gauge. The gauge consists essentially of a wide-mouthed funnel dipping into a bottle. The gauge is exposed on a suitable site under defined conditions and the deposit falling into the funnel is washed down by rain into the bottle. After a month's exposure the material collected in the bottle is taken and analysed for its various constituents such as tar, carbonaceous matter other than tar, sulphates, etc. It has been found that the records obtained with individual gauges, whether taken on the basis of monthly or annual totals, may show considerable variations and in the absence of experimental data, it is a matter of speculation whether these fluctuations represent real changes in the amount of pollution and whether they would be confirmed if the readings of a second gauge were available. It seemed desirable for this and other reasons to conduct a critical investigation on the value of the gauge itself. Work with this object was therefore put in hand for the Committee at Kew Observatory. In the course of the tests attention was devoted not only to the point mentioned but also to such matters as the effect on the deposit of the shielding of the gauge, such as by neighbouring buildings,

PRESIDENTIAL ADDRESS.

and the effect of rainfall, etc. The results of these experiments have been fully described in an interesting report which was published as an appendix to the 18th Report on the Investigation of Atmospheric Pollution, and provide valuable information in the use of the deposit gauge. So far as the main point of the investigation was concerned it was shown that the annual totals of the deposits may be taken to be correct within plus or minus 10%, thus establishing the suitability of the gauge for providing a satisfactory measure of the amount of pollution at any particular site of observation, for highly accurate figures are not to be expected of a method which of necessity has to have the merit of simplicity in operation.

Attention has also been given to such detail as the material of the gauge. The glazed earthenware funnels once used were found to be not altogether satisfactory and glass funnels are now issued as standard.

- (b) *The Automatic Filter*: The automatic filter again is an instrument used at a number of stations. The object of the filter is to obtain a measure not of the amount of impurity deposited from the air but of the impurity suspended in the air and its variation from hour to hour during the day. The principle of the method depends on the determination of the blackness of the mark produced on filter paper on drawing a known volume of air through a definite area of the paper. This determination is made by comparison with a standard scale of shades which must necessarily be reproduced accurately. The reproduction of the scales has been under further review for the Committee by Dr. Owens, the inventor of the instrument, and he has developed methods for ensuring exact reproducibility.

(2) New Methods.

- (a) *Sulphur Gases in the Air*: The work above mentioned refers to well established methods. From time to time the need arises for new methods. In recent years the importance of sulphur impurities in the air has become widely recognized. It is now known, for example, that they are responsible for

much damage to buildings and considerable public concern has been shown over the possibility that the operation of large power stations may cause the concentration of sulphur gases in the air to increase to a serious extent in their vicinity. It became clear to the Committee therefore that methods should be devised suitable for the routine determination of sulphur gases in the air, and the Government Chemist was asked to undertake the work of developing such a method on their behalf. This work has been accomplished. The new method was put into use during the year 1931-32 at ten different centres, and the results obtained formed a new feature of the report for that year, i.e. the 18th Report. The method is a simple one, in which known volume of air is aspirated through a solution of hyperol, the amount of sulphur gases absorbed by the hyperol being subsequently determined by simple titration. The equipment is not expensive; the cost of maintenance is small, and the apparatus does not involve more than a few minutes' attention on the part of an observer every day—just the time required to change the hyperol solution and to effect the titration. In view of the importance of the sulphur question, it is to be hoped that many more Local Authorities will initiate such observations.

- (b) *The Automatic Filter*: Reference has already been made to work carried out on the existing type of automatic filter. This type is dependent for its use upon the availability of a water supply as a means of aspirating the air to be examined, thus restricting the choice of site for observation. Dr. Owens has turned his attention to the development of a type which would be independent of a water supply, and has produced a practicable form of instrument which is operated by weight. As a further improvement, the new instrument can be adapted so that a record of the wind direction at the time of observation is obtained. It will be seen that the new instrument should prove particularly useful when it is desired to investigate both the amount of suspended impurity at any spot and the direction from which it comes.

PRESIDENTIAL ADDRESS.

- (c) *Daylight Measurement*: Work has also been done on the production of an improved method of obtaining in a simple way a record of the daylight received, but while this has been carried a good way, it has not yet been completed.

(3) Other Investigations.

- (a) *The Lateral Distribution of Atmospheric Impurity*: A point which inevitably comes up for discussion in connection with atmospheric pollution is the extent to which pollution from a given centre affects neighbouring areas. Very little exact information on the subject was available, and the Committee decided to investigate. The obvious general plan was to arrange for an observer to determine every day for a year or so how far down wind from a particular town the impurity from it was significant. For this purpose it was clearly desirable to choose a town having the following characteristics:
 - (a) it should naturally be as large as possible, but yet isolated, so that the results would not be complicated by pollution from other large centres of population;
 - (b) it should, if possible, have a sufficient number of roads radiating from it in all directions to make it possible for an observer easily to take his daily readings down wind whatever the direction of the wind.

Norwich, with a population of 126,207, was noted to fulfil these conditions to an admirable degree, and accordingly arrangements were made for an investigator to proceed to Norwich and make the necessary determinations for a period of a year. The Owens Jet Dust Counter was used in the determinations as being the most suitable available instrument. The data so accumulated were analysed for the Committee at the Meteorological Office and furnished interesting information. Briefly, the observations made can be summarized as showing that pollution from Norwich, as measured by the Jet Dust Counter, was significant for a distance down wind which averaged throughout the year about 5 or 6 miles. More important

still, it was found that the rate at which pollution diminished down wind exhibited relationships which made it possible to apply the results to other areas. As an example, it was deduced that in the case of an urban area of 24 miles diameter (as compared with the 2 miles diameter of the Norwich City area), the effect of the pollution would be measurable for 60 or 70 miles as compared with the 5 or 6 miles found for Norwich. This calculation, it is to be noted, is based on the assumption that pollution produced per given area of the larger district is the same as for Norwich. If it were greater or less than for Norwich the distance would be increased or diminished proportionately. Actually it was found that the air in Norwich was relatively clean, so that the investigation served to demonstrate clearly the widespread effects of pollution produced in industrial districts.

- (b) *Spread of Sulphur Pollution*:—A somewhat similar investigation is at present being conducted by Dr. G. M. B. Dobson at Oxford. Using the method recommended by the Committee for the determination of sulphur gases in the air, he has been carrying out determinations on the sulphur content of the air at Boar's Hill, which is a few miles to the south-west of Oxford. This work is still in progress, and the time is not yet ripe for any detailed discussion to be published, but sufficient has been done to show the definite influence of pollution spreading from the industrial areas to the north of Oxford.

The funds at the disposal of the Research Committee are small. Nevertheless, it is clear from the examples I have given that the co-operating Authorities have at their service an expert advisory body which is not only active in collecting and correlating the local records, but also in seeing to it that the methods at disposal are up to date and meet present-day needs, and in carrying out incidental investigations yielding information of much interest in connection with the general problem.

Co-operation With Other Organizations.

There is one other aspect of the present organization on which I think it right to dwell. Every scientific organization benefits by contact with other organizations working in allied

PRESIDENTIAL ADDRESS.

fields. The present organization for the investigation of atmospheric pollution is very happily situated in that respect. The contact with the Meteorological Office is, of course, a long standing one. Since the Department of Scientific and Industrial Research has been directly associated with the work, similar close contacts have been developed with the Fuel and Building Research Stations of the Department and with the Chemical Defence Research Department of the War Office, all of whom have valuable funds of knowledge on scientific matters related to the study of atmospheric pollution. The official status enjoyed by the organization also makes it easier to enlist the help of other bodies with which the Department has relationships as and when occasion arises. Examples of the value of these contacts are not difficult to furnish. Reference has already been made, for instance, to the help given by the Meteorological Office in analysing the results obtained in the Norwich investigation. Another instance is provided by the association of the Committee with the Building Research Station in the development of an alternative method of obtaining an index of the sulphur pollution in the air. I have referred already to the method developed on behalf of the Committee for that purpose. Cases may arise, however, for which that method may not be practicable. I have in mind cases in which it may be desired to form some idea of the distribution of sulphur pollution around a particular source, involving determinations at a number of points. The fact that the method recommended by the Committee involves daily readings may render it unsuitable for such a purpose in view of the difficulty of sparing staff to carry out daily determinations at several stations of observation. This question has been under attention at the Building Research Station, and as a result a new method has been proposed. This method was fully described in the 18th Report, but it depends, in essence, on the exposure of a standard surface of lead peroxide, and the determination of the amount of lead sulphate formed by the absorption of sulphur dioxide from the air. For this purpose the prepared surface of lead peroxide is formed on a cotton fabric which is wound on a porcelain cylinder of suitable dimensions and exposed for a month, after which it is withdrawn for examination. The method has not yet been developed to the point at which it may be recommended for general use, but it promises to be a most useful supplement to that proposed by the Committee. Trials of it are being made at a number of centres under arrangements made in collaboration with the Committee.

The collaboration of the Building and Fuel Research Stations, moreover, has made possible another recent development. The published literature on atmospheric pollution is extensive and scattered, and few of us have sufficient leisure to keep in touch with it. Arrangements for the literature to be fully surveyed and extracted would also be more expensive than funds warrant. With the help of the two Research Stations mentioned, however, a compilation of such abstracts is now prepared at little cost for issue quarterly, thus providing an abstracting service for all co-operating authorities which, though not exhaustive, is yet of definite value.

The Need for Further Observations.

Having thus described the present organization, one is prompted to ask whether sufficient advantage is being taken of it. There are, I think, several directions in which development could take place. I have pointed out that there are at present about 80 co-operating authorities, out of which about 40 co-operate by taking observations. It is clear that there are very many local authorities who have not associated themselves with the scheme and this, I think, is a matter of regret. The problem is a national one and should be studied on a national basis. The greater the number of observations taken, the greater their value, and there are many populous centres which, in my opinion, are badly advised in begrudging the small expenditure involved in the measurements, or the modest contribution needed to maintain the central organization. Furthermore, it is found on examination that for the most part the observations now being made are taken in industrial areas. Very little information is being accumulated in rural districts or so-called Health Resorts. An extension of the scheme by the co-operation of rural and seaside authorities is therefore very much to be desired, for data relating to such districts would be valuable as furnishing a standard for comparison and for indicating to what extent improvement is necessary in order that urban districts may enjoy conditions of clean air, such as are found in the country.

Again, from time to time reference is made in the annual reports issued on the observations to certain abnormal results recorded, such as a sudden increase in a particular element of pollution. It would add very materially to the value of the investigations if in such cases local authorities in question were to enquire into the cause of such results. Such enquiries might not only yield information of value, but might disclose the remedy for the trouble.

PRESIDENTIAL ADDRESS.

I would commend also another suggestion, namely, that local authorities should use the standard methods of carrying out special investigations of their own. I am encouraged to advance this proposal by the interesting data relative to sunlight determination in Halifax which are found in the last published (the 18th) report. In addition to maintaining 5 deposit gauges, Halifax arranged for sunlight determinations at two of the deposit gauge stations (Wade Street and West View Park). The results show that in December, 1931, the amount of sunlight received in Wade Street (the more heavily polluted of the two stations) is no more than just over half the sunlight enjoyed in West View Park. It will be noted that this striking record of loss of sunlight is obtained, even when the comparison is made between two stations which do not exhibit a wide range of difference of deposited impurity. I refer to the fact that the total deposit of impurity at West View Park for the year was 133 tons per square mile, whereas the minimum recorded for the whole country was 87 tons per square mile, and at Wade Street, 281 tons per square mile, as against a maximum recorded of 739 tons per square mile. One wonders what would have been the result had the daylight comparison been between stations with the highest and lowest recorded deposit, or alternatively what would have been the loss recorded at a station such as Wade Street as compared with a centre in the heart of the country. Obviously, of course, such comparisons can, in fact, only be made in terms of stations subject to the same weather conditions, i.e., stations which would enjoy the same amount of sunlight but for difference in pollution, and it would be instructive if local authorities having access to stations presenting a greater range of difference of deposited impurity than the Halifax stations were to carry out similar determinations of sunlight. No doubt there will occur to all of you other useful investigations of a like nature which could be carried out by the co-operating authorities. Certainly I look forward to greater developments in these directions.

The history which I have given you of the investigation which has taken place during the last 20 years and the interesting data which have emerged from it have, I am sure, created a sympathetic attitude of mind towards our work, and has done much to focus attention on the evil results of atmospheric pollution by the products of combustion, and I have no doubt that those authorities who have joined in the investigation do not regret their action, and have found it easier to inspire those for whose health they are responsible with the ideal and wholesome air, and with the desire for more sunlight.

RESOLUTIONS.

At the Annual General Meeting and First Conference Session on Saturday morning, September 23rd, the following Resolutions were proposed and adopted:

1. RESOLVED:

That the Ministry of Transport be respectfully requested to take the necessary steps to amend Regulation No. 18 of the Statutory Rules and Orders, 1931, made under the powers conferred upon him by the Road Traffic Act, 1930, by inserting after the word "fuel" occurring in the said Regulation, the words "*shall use only smokeless or non-bituminous fuel and.*": Provided that for the purpose of this Regulation the words "smokeless or non-bituminous fuel" shall be held to mean "fuel containing not more than fourteen per cent. of volatile matter."

2. RESOLVED:

That this Conference of the National Smoke Abatement Society welcomes the extensive schemes that are to be undertaken for slum clearance and rehousing, and as smoke, with the dirt, gloom, and ill-health that it causes, is one of the most important factors in producing slum areas, urges all authorities concerned with housing to take steps to ensure the greatest practicable degree of smokelessness in all new housing estates, whether municipal or privately built, and in rebuilt areas. In particular it urges:

- (a) That appliances for the use of gas and electricity should be installed as extensively as possible, and their use encouraged.
- (b) That where ranges for cooking and heating and open fires for the use of solid fuel are installed, they should be of a type capable of satisfactorily burning smokeless solid fuels, for the storing of which adequate accommodation should be provided.

The Conference urges the Minister of Health to investigate the position with respect to (b) above, and to make recommendations to the authorities concerned according to his findings.

Further, with a view to ensuring a parallel reduction of smoke emission from buildings other than private dwelling houses, the Conference urges the Minister of Health to take steps which will make possible the framing of byelaws under Section 5 of the Public Health (Smoke Abatement) Act, 1926.

NOTES.

Resolution No. 1. Regulation No. 18, of the Statutory Rules and Orders, 1931, referred to in the Resolution, would, if amended as suggested, read as follows:

“18. Every motor vehicle using solid fuel *shall use only smokeless or non-bituminous fuel* and shall be fitted with an efficient appliance for the purpose of preventing the emission of sparks or grit, and also with a tray or shield to prevent the ashes and cinders from falling on to the road.”

Resolution No. 2. Section 5 of the 1926 Act, referred to in the Resolution, reads as follows:

“The powers of an urban authority under section one hundred and fifty-seven of the Public Health Act, 1875, and of the London County Council under section one hundred and sixty-four of the London Building Act, 1894, shall extend to the making of byelaws requiring the provision in new buildings other than private dwelling houses of such arrangements for heating or cooking as are calculated to prevent or reduce the emission of smoke.”

Saturday, September 23rd, Conference, 1st Session.

THE FIVE YEARS CLAUSE AND OTHER MATTERS
ARISING FROM THE PUBLIC HEALTH (SMOKE
ABATEMENT) ACT, 1926.

by

Councillor W. ASBURY, J.P.,

Chairman, Sheffield, Rotherham & District Smoke
Abatement Committee.

BAILIE W. BROWNHILL SMITH (Acting President, Scottish Branch) in introducing Councillor Asbury, recalled the origin of the Smoke Abatement League of Great Britain following a meeting called by the then Lord Mayor of Sheffield in September, 1909.

Since those days the League, and the Society as it now was, had not done all that it would have liked to do. That was because it was fighting against a wall of indifference and apathy. Lord Newton told them long ago that Britain had the filthiest atmosphere in the world and he was afraid that the statement might truthfully be repeated to-day. At the same time things were getting better, and not that scientific people, engineers, and inventors had made it possible, there was no reason why, within the next few years, smoke should not be eliminated from Britain. Bailie Smith then called upon Councillor W. Asbury to present his paper.

Councillor Asbury then read his paper:

As doubtless you are aware, the Public Health (Smoke Abatement) Act, 1926, is a subsidiary Act, passed for the purpose of strengthening the provisions of the Public Health Act, 1875, relating to smoke nuisances other than from chimneys of private dwelling houses, and it may be regarded as not inappropriate at this conference, which is taking place six years after the coming into operation of the Act, to examine its advantages and drawbacks, with a view to satisfying ourselves on the one hand that none of its advantages have been overlooked or forgotten, and on the other hand so far as its drawbacks are concerned, examine them in the light of the experience we have gained, and then proceed to consider what is the appropriate action to be taken to remedy the defects which are apparent to those of us engaged in its administration.

The 1926 Act did for the first time enable local authorities to deal with smoke other than black smoke as a nuisance.

THE FIVE YEARS CLAUSE.

It included in the expression "smoke" soot, ash, grit, and gritty particles.

The maximum penalty for committing a smoke nuisance was increased from five pounds to fifty pounds.

The Minister of Health was given power, after a public inquiry and after consultation with any local authorities or other interests concerned, to make orders—

- (a) extending the list of noxious or offensive gases mentioned in section twenty-seven of the Alkali, &c., Works Regulation Act, 1906; and
- (b) extending the list of works mentioned in the First Schedule of this Act.

Local authorities were enabled to make bye-laws requiring the provision in new buildings, other than private dwelling houses, of such arrangements for heating and cooking as are calculated to prevent or reduce the emission of smoke.

Power was given to two or more local authorities to combine to carry out their duties in respect of smoke nuisances.

It was provided that if the County Council resolve that a local authority within the county have failed to carry out their duties in respect of smoke nuisances, subject to certain procedure prescribed, those duties could be transferred to the County Council.

Power was also conferred on local authorities to undertake research into problems relating to atmospheric pollution, and the abatement of smoke nuisances.

The foregoing are, we believe, the main advantages accruing from the passing of the 1926 Act, and we might pause here, in order that those of us present, who are representing local authorities, may give adequate reasons, if any, for not having made full use of the provisions already referred to.

How many local authorities have taken the trouble to deal with smoke other than black, and tackle the problem of excessive emission of soot, ash, grit, etc.?

Are we really to believe there has been no circumstances existing which would have justified an application for an extension of the list of noxious or offensive gases mentioned in the Alkali, &c., Works Regulation Acts, 1906?*

What steps, if any, have been taken to make bye-laws to compel arrangements to be made in new buildings to prevent or reduce the smoke nuisance?

Are we satisfied that in only one area it has been con-

* Since drafting the paper I have learned that a number of additions and extensions have been made in the Alkali, etc., Works Order, 1928.

THE FIVE YEARS CLAUSE.

sidered desirable and necessary to set up a Statutory Committee?

Does anyone present know of a single County Council that is concerned with the question of atmospheric pollution? If not, is it to be expected that any application is likely to be made to the Minister of Health for powers to carry out the duties of a local authority which has signally failed to tackle this problem, as a number undoubtedly have?

What real research has been undertaken by the various local authorities, particularly on lines relating to problems peculiar to given areas, apart from the Standing Conference of Co-operating Bodies associated with the Department of Scientific and Industrial Research?

Those of us who are unable to give satisfactory answers to these questions must not be surprised if, in any request we make for stronger powers, we are reminded of existing powers not yet made use of, and a deaf ear turned to our request.

Any shortcomings of ours in the direction already indicated should not, however, deter us from considering to-day the drawbacks of the 1926 Act, for is it not our duty to be prepared, at the appropriate time, to submit proposals, the effect of which should be to remove them?

The Five Years Clause.

We would specially direct your attention to what we consider to be the greatest drawback, and one that directly concerns this area, commonly referred to as the five years clause. We quote the relevant sections of the Public Health Act, 1875, and the Public Health (Smoke Abatement) Act, 1926.

Section 334 of the 1875 Act states that

“nothing in this Act shall be construed to extend to the smelting of ores or minerals, nor to the calcining, puddling and rolling of iron, and other metals, nor to the conversion of pig iron into wrought iron, so as to obstruct or interfere with any of such processes respectively.”

Section I., Sub-section (e) of the 1926 Act, read as follows:

“Section 334 of the Public Health Act, 1875 shall have effect as if there was included among the processes specified in the section the processes of reheating, annealing, hardening, forging, converting and carburising iron and other metals, and if the Minister of

THE FIVE YEARS CLAUSE.

Health make a Provisional Order to that effect, any other industrial process specified in the Order:

Provided that the Minister may by provisional order at any time after the expiration of five years from the passing of this Act exclude from the application of that section any processes specified in that section, as amended by this paragraph so far as smoke nuisances are concerned."

This Sub-section was included in the Act as a result of representations made to the Government by the Sheffield Manufacturers, who claimed that it gave them an unqualified exemption with respect to the processes referred to, a claim which was not accepted by the Statutory Committee, because read in conjunction with Section 334 of the Public Health Act, 1875, it will be appreciated that any action taken by the Committee could succeed if it was proved that in abating the nuisance it would not obstruct or interfere with any of such processes. In addition, the Sheffield Public Health Committee had been able, for a number of years past, to obtain Magistrates' Orders in respect of excessive smoke emission from certain of the furnaces where special processes were carried out.

It was realized, however, in view of the attitude of the Manufacturers that to proceed by way of prosecution would not only involve us in expensive litigation, the cost of which if we were unsuccessful, would have to be borne by the rate-payers, but would create a bitterness between us which could only have led to disastrous results, because under such circumstances co-operation for purposes of research, which might provide real and lasting solutions to the various problems, would have been impossible.

It should be stated that the Manufacturers had already accepted our standards as reasonable so far as they related to boiler smoke and, as they are still in operation, for the purpose of reference they are set out below.

Where there is one boiler attached to the chimney 2 minutes per hour.

Where there are two boilers attached to the chimney 3 minutes per hour.

Where there are three boilers attached to the chimney 4 minutes per hour.

Where there are four or more boilers attached to the chimney 6 minutes per hour.

With regard to furnace and combination chimneys, we decided not to institute proceedings, but to endeavour to

secure the co-operation of the Manufacturers in the setting up of an Advisory Committee for the purpose of research, and after a series of conferences in 1929 the Committee was constituted under the chairmanship of Professor Desch, consisting of representatives of the Manufacturers' Association and the Statutory Committee, it being agreed that research work should be instituted at our joint expense. Apart from a change in the Chairman when Dr. Desch left Sheffield, and Professor Wheeler took his place, the work has continued, almost without interruption, until the early part of the present year.

At the meeting of the Joint Advisory Committee held on June 27th, last, when the last Progress Report of the Research Committee was submitted and approved, the Chairman, Professor Wheeler, stated that

“so far as metallurgical processes were concerned, he was satisfied that such processes could be carried out, with suitable plant, without excessive smoke. He did not think, however, that it could be expected that Manufacturers would agree to scrap existing plant which had cost thousands of pounds, to instal new plant.”

It is only fair to state that, in addition to the research work carried on, which has resulted in the opening up of such possibilities, certain firms have carried out a great deal of experimental work at their own expense.

So satisfied are the members of the Statutory Committee with the progress made on the industrial side that it has been decided to conduct investigations into the domestic smoke problem, the question of contributions towards the cost of such work having been left in abeyance for the present.

In the meantime, we have to consider what attitude we should adopt with respect to the qualified exemptions contained in the 1926 Act, the period of five years having expired, and if it is thought necessary, local authorities can now call for an inquiry to request the removal of those exemptions. The question we are called upon to answer is—will it help to any extent if these exemptions are removed from the Act?

We are suffering from world-wide trade depression, and there appears to be no possibility of business resuming normal conditions in the near future. Would it be fair and reasonable to ask Manufacturers to scrap all their existing plant and put in new plant immediately? Are they in a financial position to do so? If not what is the alternative?

Can we leave the Act as it is, and trust Manufacturers to

THE FIVE YEARS -CLAUSE.

reconstruct their furnaces on right lines and help us in our work of cleaning the atmosphere?

Unfortunately we already have evidence of reconstruction work carried out where the furnaces have been rebuilt, where new furnaces have been installed, on the old uncontrolled method of smoke making. They offend every law of combustion and will never give satisfactory results.

If we leave the Act as it now stands everything will turn on the phrase "that nothing in this Act shall be construed to apply to metallurgical processes so as to obstruct or interfere with the efficient working of such trade processes." How will magistrates interpret this if it is found necessary to bring cases before them?

These are vital questions affecting the health and happiness of this large industrial population.

If we had the full confidence that every manufacturer would do his share in the reconstruction work necessary there would be no doubt that the Act could remain in its present form, and we should be satisfied with the definite knowledge that it was proceeding as fast as circumstances would permit. We would wish that the evidence were a little more clearer on this point.

We want to make much greater headway in cleaning up the air, and this can only be achieved, so far as the industrial smoke problem is concerned, by the fullest co-operation and goodwill on all sides. We hope it may be possible to obtain it, because the alternative is to make application to the Ministry for the removal of those qualified exemptions, which if successful, would lead to action being taken that could only have one result, a feeling of bitterness and resentment, and this I am sure we are all anxious to avoid.

So much for the five years clause.

Bye-Laws.

Section II. of the Act gives local authorities power to make bye-laws regulating the emission of smoke of such colour, density and content as may be prescribed, but there is no mention of a "Time Standard" for the smoke emission. Any bye-laws that have been granted under this Section have been for "black" smoke only, and though the Ministry put forward, as a general recommendation, that a uniform time standard of two minutes smoke per half hour should be aimed at, time standards throughout the country are many and varied.

There are hundreds of chimneys that emit smoke other than "black" smoke. The lowest form of steam generator,

the vertical boiler using coke or a mixture of coke and coal, never emits black smoke. Pulverized fuel generators give out yellowish or white smoke, and incinerators and Public Works Destructors emit the same. Of what use are bye-laws for black smoke in cases as these?

Bye-laws undoubtedly simplify the method of procedure for dealing with smoke nuisances and enable pressure to be brought to bear on persistent offenders much more quickly than having to rely on the Statute. It takes at least three months before pressure can be brought to bear on an offender when working under the 1875 Act.

A certain amount of research work has been carried out in order to produce, if possible, an instrument capable of measuring the various densities of smoke, and some measure of success has been achieved, but on "black" smoke only. The number of variants that have to be accounted for, however, make it doubtful if the instrument will be of practical use. The greatest obstacle to instrument reading of any kind is the publicity during observation periods, so that normal conditions from the chimney are seldom shown.

There may be other points that will occur to you as worthy of consideration, and I trust that they will be referred to in the discussion. You will observe that I have made no detailed reference to the domestic smoke problem. The reason for that is not any desire on my part to minimize its importance, but as it is to be the subject of another paper I did not feel it within my province to trespass on the grounds which will be covered, I have no doubt, very well by others.

In closing, I hope you will forgive me making a further reference to Statutory Committees. I am surprised and disappointed that, after a period of six years, no other area has followed our excellent example. I shall keep stressing the need for them as preferable to Regional Advisory Committees.

Even from an economic point of view the forming of Statutory Regional Committees is a proposition worthy of consideration. If you doubt it look at our balance sheet for the past three years. The cost to the smaller authorities is only a few shillings per week. Uniformity of action and expert advice on our common problems are given throughout the area. The "vested interests" trouble which small authorities experience does not apply. Atmospheric pollution records can be undertaken in a manner that is almost impossible elsewhere.

I know that we are somewhat unique in having so many other local authorities in close proximity to Sheffield, but

THE FIVE YEARS CLAUSE.

there must be scope in other industrial parts of England for the setting up of Statutory Committees.

As a matter of fact our methods are primarily advisory, but when they fail we are in the fortunate position that our decisions have the force of law behind them.

That we are on right lines there can be no doubt, and I am quite certain that in a few years time we shall have achieved such a measure of success in the work we have undertaken that we shall be able to point out that though this area was at one time perhaps the most notorious in the country for industrial smoke, the picture of it will then be much more in harmony with the beautiful frame by which it is surrounded.

DISCUSSION.

Dr. H. A. FELLO (Sheffield Gas Company) said that he was not in a position to answer many of the leading questions in the first part of the paper, but he did wish to refer to the section on the Five Years Clause, and its immediate bearing on the position in Sheffield.

Councillor Asbury had paid tribute to the excellent work done by the Sheffield Manufacturers' Smoke Abatement Committee, and had mentioned the opening up of big possibilities as the result of the work done experimentally by certain manufacturers at their own expense. He had also referred to the statement by Dr. Wheeler, the Chairman of the Research Committee that "so far as metallurgical processes were concerned, he was satisfied that such processes could be carried out, with suitable plant, without excessive smoke."

This was a most important statement, and had been endorsed by many of the leading steel manufacturers of the district. But it did not mean that the smoke pall of the district had now to cease, by law. The suitable plant, referred to by Dr. Wheeler, should be produced. It should be demonstrated and proved successful. It was of little use to say "Use a furnace which consumes its own smoke," or "Use a fuel which does not make smoke" unless a practical demonstration of such a furnace, or such a fuel, could be given. Not only that, but it should also be demonstrated, and not merely stated, that equally good results could be obtained with the metal under treatment, and at an economic price. Might he suggest that furnaces, working satisfactorily in every way on production, and making no smoke, seen by the steel manufacturers, would help far more in combating the smoke nuisance than any amount of "forceful persuasion."

That the prevention of smoke was a sound method of ensuring fuel economy was not news to a steel manufacturer. He himself regretted the amount of fuel wasted up the chimney, and would at once take steps to prevent this waste if he could see a way of doing it economically and without damage to his material.

THE FIVE YEARS CLAUSE.

Dr. Fells referred to Councillor Asbury's statement that "If we had the full confidence that every manufacturer would do his share in the reconstruction work necessary there would be no doubt that the Act could remain in its present form and we should be satisfied with the definite knowledge that it was proceeding as fast as circumstances would permit." He wished that the evidence on this point was a little clearer. In his present position with the Sheffield Gas Company it was possible for him to see very clearly much of what was happening with regard to the abolition of industrial smoke. He had noticed that in the Third Annual Report of the Smoke Inspector that "although the use of gaseous fuel is making progress in Sheffield, it was not going forward with the expedition that was hoped." In answer to that statement, and in the hope of giving Councillor Asbury evidence that manufacturers were proceeding as fast as circumstances permitted, he was in the position to say that the use of gas for industrial purposes was increasing in Sheffield at a phenomenal rate. During the past two years, and particularly during the past nine months, many instances of replacements of solid fuel by town's gas could be cited. This large increase in the amount of gas was not merely due to the re-starting of existing gas-fired furnaces, but principally to the wholesale conversion of solid fuel fired furnaces.

At the present time four of the largest firms in the city were converting entire shops to the use of town's gas, necessitating the erection of batteries of furnaces and not merely single furnaces. These old offenders, sheet furnaces, were being replaced by gas-fired furnaces, and batteries of them had been installed by some of the largest firms in the city. At the present time similar conversions were being made by two other Sheffield firms, and it required no political coercion to make manufacturers use gas to prevent smoke, or town's gas as fuel, were used. They were used not simply to prevent smoke, but because it was an economic project to do so. It was not politic to give actual figures of the increased gas consumptions, or names of firms making these big conversions from solid fuel to gas, but he was persuaded that as far as town's gas was concerned, the local steel manufacturers were taking every advantage of new forms of gas-fired furnace, whenever circumstances permitted.

Mr. H. C. ARMSTRONG (Fuel Officer, Messrs. Thos. Firth & John Brown Ltd.) said that as he came from one of the Sheffield manufacturing firms he might be considered to be in the enemy's camp, but that was not really the case, and as the greater part of his time was spent in trying to get economy in the use of fuel he was heartily in accord with the cause of Smoke Abatement. He said he had read Councillor Asbury's paper with great interest and would like to compliment him on his moderation and fair review of the position. Although at the works they did not always welcome the visits of the Smoke Inspector with open arms, at any rate they were

THE FIVE YEARS CLAUSE.

on friendly terms and did all they could to meet their complaints. He thought that in few cities were the Smoke Inspectors of the Health Authorities and the manufacturers on such amicable terms as in Sheffield.

Although the representative of the Sheffield Gas Company had just said the increase in the use of Town Gas was enormous he thought that expression was not quite right. The increase in the use of Town Gas had come, but if only the price could be made more reasonable its use would jump to a really wonderful extent. His own firm had built no new raw coal fired furnaces during the past two years, installing gaseous fuel in every case. Councillor Asbury had mentioned the various times permitted for the emission of black smoke for boilers, but everyone knew that the regulations were broken again and again. A railway journey to London showed heavy smoke issuing from boiler chimneys in many places. If the present regulations were adhered to it would not be necessary for any fresh laws. Mr. Armstrong's firm were now manufacturing a boiler smoke eliminator which was completely successful on every class of boiler, including those in use on tugs, as installations on the Tyne and Thames had conclusively proved. Better efficiency was obtained and black smoke eliminated. The question of metallurgical furnaces was different as the capital cost of conversion must be taken into account. He reckoned that roughly thirty shillings per ton of coal burnt annually would be needed to convert to gas firing. As some of the furnaces used 40 or 50 tons per week it would seem that the cost could only be faced piecemeal.

In conclusion he emphasized the fact that the local manufacturers were working to improve things along with the Health Authorities and that it was quite unnecessary to make any alteration in the present laws.

Mr. WILLIAM NICHOLSON (Ex-Smoke Inspector, Sheffield) said that in the Public Health Act of 1875, and in the 1926 Act, there was all the protection the manufacturers needed for every kind of furnace or metallurgical process, and the Acts included all the powers required by local authorities to take proceedings for unnecessary smoke, the prevention of which would not obstruct or interfere with trade or processes. The 1926 Act did not repeal that of 1875, but was an Act of reference.

Section 1, Sub-section (1) (e) of the 1926 Act gave protection to the reheating, annealing, hardening, forging, converting, and carburizing of iron and other metals; but this was not necessary for the said processes, as they were adequately protected, up to the point of practicability, by Section 334, and Section 91, of the 1875 Act.

For over fifty years the local authorities throughout the country, with few exceptions, had been guilty of dereliction of duty, by

THE FIVE YEARS CLAUSE.

refusing to administer the smoke abatement sections, and slaughtering the people wholesale with smoke.

A few local authorities had appointed special expert inspectors, who had administered the Acts with satisfactory results, but the rest had not done their duty nor appointed special smoke inspectors. Neither had the Ministry of Health taken the necessary steps to compel them.

A few advisory committees had been appointed, but they had no statutory powers to visit the works and ascertain the amount of smoke made unnecessarily for the various manufacturing processes. And if the said committees did possess the expert knowledge to advise the smoke makers on practical and profitable smoke prevention, the smoke makers could, and would, refuse to take notice of them. Section 6 of the 1926 Act gave power to local authorities to combine and appoint joint committees for carrying out their duties in respect of smoke nuisances. It was a scandal that after seven years from the passing of the Act that Sheffield was the only one that had had the conscience and the courage to form a statutory committee. It was absolutely necessary, if the smoke Acts were to be satisfactorily administered, that local authorities should combine and appoint statutory committees.

Such committees should, when formed, appoint specially qualified inspectors possessing engineering, chemical, metallurgical, legal, and other knowledge to be able to give the necessary advice to smoke makers, and to demonstrate at the fireplace or furnace how to prevent unnecessary smoke; and also able to satisfy the courts, when necessary, that the smoke complained of was not necessary and the prevention of it would not hinder trade, but would help it by reducing coal consumption.

If local authorities were determined to continue their dereliction of duty by refusing to establish statutory committees, which was the only satisfactory way of administering the smoke Acts, and if the Ministry of Health refused to take action, then it was for the public to demand action, if they wanted an unpolluted and unpoisoned air: an atmosphere fit for a civilized people to breathe.

Mr. G. S. FRANCIS (British Electrical Development Association) stated that during a recent visit to Germany he had occasion to visit Dusseldorf, Essen, and other industrial towns situated in a district whose industrial output was very similar to that of Sheffield and its neighbourhood. But German towns were very different, being brighter cleaner, and in every way more humanly pleasing. This result was doubtless due to the fact that electrical and other smokeless methods entered much more largely into industrial process and domestic practice than was the case at home. There was also a generally held opinion regarding the nature and use of coal and the emission of smoke that differed widely from the apathy that seemed to prevail

THE FIVE YEARS CLAUSE.

here. Throughout the Ruhr district coal seemed to be regarded as too valuable a material to be wasted merely as a raw fuel, while there seemed to be as much civic pride taken in the cleanliness and appearance of the towns as we took in the cleanliness and appearance of our persons. These remarks did not imply any suggestion that we should copy Germany—we possessed ample material means and technical skill to do all that was necessary in our own way—they did, however, suggest that if certain trades and industries could be carried on in a relatively cleanly fashion in one place they obviously could in another, if the will was there.

Mr. JOHN W. BEAUMONT (Halifax Corporation) said that the reply to the query "How many local authorities had taken the trouble to deal with smoke other than black?" was that although the Public Health (Smoke Abatement) Act of 1926 gave power to local authorities to make byelaws regulating the emission of smoke of such colour, density, or content as might be prescribed by the byelaws, the Minister of Health had, up to then, refused to confirm byelaws other than those dealing with black smoke. Local authorities were in the position, therefore, of having to deal with a reactionary best-practicable-means clause which, for the first time, introduced such matters as cost, local conditions, and circumstances, which rendered it almost unworkable.

Again, it was asked what steps, if any, had been taken to make byelaws to compel arrangements to be made in new buildings to prevent or reduce the smoke nuisance. To this Mr. Beaumont replied that it was well known that the Minister of Health had stated that he was advised that at present it was impracticable to carry out such byelaws and that he could therefore not confirm any which were submitted to him.

Respecting the necessity of setting up Statutory Committees, he submitted that a satisfactory case had not yet been made out, and that the author himself referred almost exclusively to the value of co-operative work. Could not such work be carried out equally well, if not better, by a Committee established on an advisory basis?

The West Riding of Yorkshire Regional Smoke Abatement Committee was the first and only committee to tackle the question of the training and examination of stokers and boiler attendants upon a broad and comprehensive basis. As a result of the success achieved in this direction, it was hoped that very shortly there would be instituted a scheme of training and examination which would embrace the whole country. This was a striking example of invaluable work carried out by a committee established upon an advisory basis.

BAILIE ALEX MUNRO (Glasgow) pointed out that in the Scottish Act relating to smoke emissions there was no mention of black smoke. The emission of smoke of any colour in such quantity as to be a nuisance or injurious or dangerous to health is an offence

THE FIVE YEARS CLAUSE.

against the law. A smoke eliminator had been mentioned in the discussion, but such appliances were merely smoke diluters. Prosecutions, he believed, were of little value; many firms said, in effect, that if the bill was sent in at Christmas they would pay it for the whole year.

Mr. H. C. ARMSTRONG replied later to Bailie Munro's criticism of smoke eliminators, and said that although the Conference was not the place to advertise, he had no hesitation in repeating that the Eliminator in question would stop all smoke emission within the meaning of the Act from any class of boiler. They had now several installations up and down the country, including tugs on the Thames and Tyne, Lancashire boilers in well-known London factories, road and rail locomotives and vertical boilers. The apparatus was put on the market by the British Smoke Eliminator Company, Ltd., 52a, Queen Anne's Mansions, S.W.1., and was made in Sheffield by his own firm.

COUNCILLOR C. E. KEENE (Leicester Corporation) said that there seemed to be a depression over the Conference that morning, but he suggested that there was no cause for pessimism in view of the work done since the war. A more hopeful view should be taken of the work done by the National Smoke Abatement Society. He considered that the right place to start smoke abatement was in the schools, and that the subject should be taught, especially to girls between the ages of 12 and 16, before they left school. In Leicester the ill effects of air pollution was being taught in the science classes. He was pleased to be able to tell the Conference that only that week the Leicester Education Committee had decided to introduce the subject into the intermediate schools.

Mr. T. E. BIRTWISTLE (Castleford U.D.C. and the Sanitary Inspectors' Association) said that he wished to thank Mr. Councillor Asbury for his paper, but he thought too little regard was being paid to the good work being done by Regional Smoke Abatement Committees of an advisory character, as distinct from Statutory Committees. He had been a member of the West Riding Regional Committee (an advisory one) since its inception, and he could testify to the influence it was exerting amongst the local authorities it represented. Much had been done to obtain uniformity of administration, and one of its more recent activities had been to establish courses of instruction, and to hold examinations, for boiler stokers.

On the question which had been raised of the compulsory use of smokeless means of heating, he thought that while this might be practicable in certain continental countries, our British mental outlook was such that it was hopeless to expect any legislation to that end. There was, however, a reasonable prospect that before very long the research work and experiments being made at the present time would result in there being rendered available great quantities of smokeless fuel for both industrial and domestic purposes.

THE FIVE YEARS CLAUSE.

ALDERMAN C. LUCAS (Birmingham) said that persuasion was the best policy to pursue with a view to getting manufacturers to reduce their smoke. He considered that there would be a considerable improvement with the recovery of trade, as it would then be possible to replace old by modern plant, with a reduction in smoke emission. It would be valuable if mass production methods could be used to reduce the price of plant. In reply to what had been said about the smokeless conditions of Essen, he would like to point out that in this city everything was under the control of one firm, which was able to insist upon smokelessness.

Mr. HARRY PRIESTLEY (Chief Sanitary Inspector, Blackpool) stated that from the opinions expressed by the metallurgical experts it would appear that the question of the abolition of the smoke nuisance from furnaces was entirely one of finance. If the necessary monies were forthcoming for the conversion of the furnaces from coal to gas fired, manufacturers would greatly welcome the change even though it was still cheaper to use the raw fuel than burn gas. This conversion would assist in reducing the great unemployment in the iron and ancillary trades, and the proposals ought to receive sympathetic consideration from the Government at present in power.

In assisting Industry a marked improvement in the atmosphere would result which must of necessity contribute to a healthier race of people.

It did not necessarily follow that because Sheffield and district by means of a statutory Committee had been successful in alleviating the smoke nuisance that the same result would not have been achieved by an advisory body. The West Riding of Yorkshire had also achieved a great deal in atmospheric purification, and this had been accomplished by means of an advisory Committee.

There was certainly room for much more collaboration between authorities in tackling this difficult problem, and joint efforts, whether of voluntary or statutory character, were to be encouraged.

Mr. G. J. GREENFIELD (Works Manager of Thorncliffe Coal Distillation Limited) said that he was a member of the Wortley Rural District Council. The Wortley District was one which the Sheffield, Rotherham and District Regional Smoke Abatement Committee would like to have as a member. They had so far declined to join the Committee because their primary object was to enable people to live by keeping down the rates and by not forcing manufacturers to spend money which they could not afford. Without saying anything about the Company with which he was employed, his experience on the District Council showed that other manufacturers in the district were also amenable to reason and always did what they could to abate any smoke nuisance which was complained of. It therefore seems unnecessary, in their district at any rate, to adopt statutory powers.

THE FIVE YEARS CLAUSE.

Reference had been made to the great degree of modernization in German works. It must be remembered that German currency had been depreciated to infinity, thus impoverishing everyone in Germany except those who had the most. Advantage had been taken of this curious state of affairs to modernize industry at very low cost. Did the Conference consider it desirable to depreciate our currency in the same way?

COUNTY COUNCILLOR G. A. GRIFFITHS (West Riding of Yorkshire C.C.) said that as a miners' representative he could speak from the standpoint of the coal producer, the ideal of whom was that there should be as much coal as possible consumed. In the West Riding County Council a resolution had been passed by which preference would be given to stokers who had passed examinations in proficiency.

Councillor W. Asbury replied to the points raised in the discussion.

HOW THE CITIZEN TAKES THE AIR: THE
PERSONAL SIGNIFICANCE OF THE
SMOKE PROBLEM.

By Mrs. MILLICENT JAST.

Dr. J. RENNIE, M.D., D.P.H., Medical Officer of Health for Sheffield, in opening the session, quoted statistics indicating that the health of the city was very good, even in regard to respiratory diseases. The city mortality figures showed, he said, that Sheffield compared very favourably with any other city and with the country as a whole. One might expect Sheffield to have a very high incidence of bronchitis. They admitted, frankly, that Sheffield was not a smokeless city, but in spite of this the mortality rate from bronchitis was very much less than the rate for the country as a whole.

The same observation was true in regard to tuberculosis. In Sheffield, tuberculosis of the lung had a smaller death rate than it had in any other town having a population of over 200,000, with the exception of Croydon.

The vital statistics for 1908-10 showed that the average death rate for England and Wales from pulmonary tuberculosis was 1,076 million living, and for Sheffield it was 1,113. The rate for respiratory diseases other than tuberculosis, i.e. bronchitis, pneumonia, and so on, for England and Wales during that period was 2,480 per million living, and for Sheffield the rate was 3,075. This was about the time the Smoke Abatement League started. To-day the position was reversed. Of course, they found that there was a large decrease, in England and Wales, of the mortality rates from the diseases referred to. In the case of respiratory tuberculosis the death rate for England and Wales averaged about 723 per million living for the period 1930-32. The rate for Sheffield for that period was 682.

If they took the figures for respiratory diseases with the exception of tuberculosis they found that the rate for England and Wales during 1930-31 was 1,452 per million and for Sheffield, 1,268. It would seem, therefore, that there had been a very great improvement in the health statistics of Sheffield during the period the Smoke Abatement Society had been working.

He recognised that mortality statistics were rather antiquated nowadays. They were out purely for the prevention of disease, and surely excessive smoke was one of the first things to be prevented.

Dr. Rennie then called upon Mrs. Jast to read her paper.

Mrs. Jast then read her paper:

Let it be said at once that in thus addressing the converted, I despair of adding any new idea to what they have already heard, read, or thought on this subject. But until the evil is removed, we must not cease our verbal war, in the hope that the clash of conflict may perchance prove loud enough to arouse the community at large to a sense of the error of its ways. A recent correspondent in the "Times" expressed a preference for under-statement as the more emphatic persuasive for reasonable people: whilst applauding this as a general principle, I feel that the following remarks scarcely accord with it, and indeed may be open to the criticism of special pleading, but at least I can urge that the case against air pollution by the consumption of raw coal cannot be overstated, and that its arguments are directed not against reasonable people, since these are already supporting this Society, but to the rest of the forty million inhabitants of this country whose description I leave with Thomas Carlyle.

* There is one essential process of life that gives us a satisfaction that age cannot wither nor custom stale—the subtle interchange by which our blood is purified and stimulated by aerial admixture. The more closely we probe into the nature of matter, the more diaphanous does its texture appear, but the miracle of interfusion of the circumambient, invisible, and intangible element with our own substance is calculated to deepen our reverence for the body and intensify the enchantment of life. Ignorance may leave us incapable of apprehending the mechanical process, but a healthy instinct suffices to ordain that after our days spent in the unnatural seclusion of office, workshop, mine, or mill, we must to make the most of our freedom, take the air to promote and restore our physical harmony as far as possible. For our specific purpose, we propose to analyse our experiences with their conditions and consequences. But let us begin at the very beginning, and consider first the initial breath which potential humanity draws in smoke-laden slums in every urban community in this Kingdom. Every M.O.H. will tell the same tale—that the infant during gestation is hardly affected by the external conditions of its parents; the size and physical quality of the average babe at birth varies little between Hampstead and Bermondsey, but while bonnie youngsters thrive in one district, they are slain or stunted by the foul air in the other. So for example, in Manchester we find that whereas in three outlying suburbs the annual infant mortality rate averages 57 per 1,000, in three central areas, the rate averages 109 per 1,000.

HOW THE CITIZEN TAKES THE AIR.

Some of the youthful citizens therefore express their view of taking the air pretty definitely. Their conditions are not simply and solely a matter of poverty. Equal lack of means obtains in many a rural district where babes do not dwine (as the old word has it)—where fresh air can sweeten the bed-chamber, and statistics show the result. Compare the figures as quoted last year—the average infant mortality rate for County Boroughs was 74.4 and for Rural Districts 55.5—that is a death rate of at least 19 per 1,000 entirely due to the unnatural conditions sanctioned by the community for popular existence. For brevity's sake it may be permitted to call this difference of 19 per 1,000 a murder rate.

Facts Behind Figures.

We are so fearful of being charged with sentimentality—with an unscientific way of dealing with the facts of life—that we shrink from analysing the personal significance of statistics, but it is clear that nothing short of realism will move to action—that mathematics are too pure and good for human nature's daily food, and we must look to the tears of bereaved parents, the sick despair of the mother looking back on weary months of hopeful expectation, to inspire effective action.

It was of no sentimentalist, but of a clear-sighted business man that his daughter, Lady Rhondda, writes as follows: "He burrowed into the mass of statistics (at the local Government Board); the one that horrified him most was the infant mortality rate. During 1915 110 babies under one year had died for every 1,000 born about 50,000 babies died needlessly every year. He had a horror of unnecessary waste: he was more conscious than most of the sacredness of life, to him a gift of inexpressible value he always built for the future: he had a special reverence for children etc." ("This was My World," p.202.)

It is a matter of public regret that energy so inspired could not have had a chance to work out some scheme of salvation which would have reconciled a low infant mortality rate with the needs of the coal trade: we see the waste in life not only in the leakage of youth, but in the anxieties of the birth period, the necessary labours of nurses and doctors: the costly social machinery, to say nothing of the burdens and pangs of parents, all reduced to absolute futility when the undertaker has to dispose of the pitiful issue. The infant might naturally query—

"If so soon I must be done for
What on earth was I begun for?"

Such an elaborated view does perhaps for a moment enable

us to recognize air pollution for the criminal and murderous procedure it actually is. That one effect, the slaughter of the innocents, should suffice to rouse our social conscience, but the Herods of our time are too many, and each clings to the glow of comfort in his hearth, regardless of consequences.

Serious as child loss is intrinsically, we have to remember that it is not merely a matter of cutting off so many embryonic entities: what I have called the murder rate is but an index to a much larger but unrecorded total representing survivors who become maimed and halt by reason of their early struggles. Figures of those who have become malformed through rickets are not available, but in many cases, we know that the hopes of expectant mothers are rendered abortive through the conditions of their childhood. It is also important to remember that this is a contributory cause to the excess of women over men in this country; as although every year the rate of male births is in excess of the females, the mortality amongst the males is greater, and is very largely due to the inadequate physical development of the mothers. We are told again and again that rickets is a disease of darkness—that where sunlight can promote vital energy, development is unchecked: to the extent, therefore, that we blot out the sun, we cast a blight on life at its very source, and if man wishes to predominate in the community, let him arrange for a fair start. Women and children first! Let them take the air in its natural purity, and men will reap the reward by losing the fear of “the monstrous regimen of women” by which they are now haunted.

Fire-worship and Human Sacrifice.

At these conferences we have been reminded so often of the promotion of respiratory disease due to air pollution that I need do no more than refer to it as one of the personal troubles that pursues the citizen throughout his urban life. If the Press, which enjoys creating a clamour about the dangers lurking in milk supplies or public baths would only turn its attention to the far more certain and insidious contamination seated in that element which every one bathes in and absorbs from birth till death, it would be far more deserving of our gratitude and respect. Whilst straining at the gnats which buzz in the hot air of Fleet Street forcing-houses, the nation is in process of extinction by choking with a camel! We absorb about 35lbs. of air daily—or 7 times the weight of food and drink combined. Surely common sense would seem to demand that the largest interest of man would be his prime concern: that it would at least be safeguarded

HOW THE CITIZEN TAKES THE AIR.

as rigorously as our water works. (Do we not know that it is forbidden to keep poultry in the near vicinity of Thirlmere in the interest of the Manchester water supplies?). But no: man wants not only air but warmth. He has discovered a form of chemical combustion which gives this, and on the altar of his fire-worship he offers up himself as a living sacrifice. Great and glorious was Moloch of old: splendid his ceremonies, fierce the glow and fell the flame that issued from his open jaws. In the Canaanitish festivals infants were annually sacrificed in his honour: it has been left for this country to establish a system of daily, hourly, sacrifice that would have appalled the priests whom we condemn as barbarians. Our climate is mainly responsible for our psychological inertia: warmth and the fire glow are such comfortable contrasts with wintry conditions that traditional means of securing both must not be challenged. Truly Landor was literally accurate when he said "I have warmed both hands at the fire of life"—for it is life actually burning behind the coat-tails of the pompous parent as he expands himself on the hearth-rug, whilst keeping his family in the cold.

But 50% of our infants at least survive, and the young citizens in due course take the air "on their own." A large proportion find themselves in quarters lined with bricks and mortar, in which no green thing can live. Our larger cities all have regions where the schools have stony playgrounds unrelieved by a leaf, whence a long tram or bus ride is required to reach the subsidized parks. Even in Oxford, we read of efforts now being made to counteract this new squalidity which has followed industrial development by arranging for summer classes in the suburbs—with happy results. Why is it that these expensive schemes to supplement the expensive school provision are required? Simply and solely because with the crowding up of dwellings, our defective heating systems concentrate their murderous effects on the most populous localities. If an odd shell or two containing poison gas be accidentally exploded, public inquiry is vociferously claimed, but when poison gas is eliminated every day and all day long by millions of chimneys, so that the little citizens blacken their lungs by every breath taken, and pursue their play in a world where the garbage in the gutter is their nearest acquaintance with the natural beauty of the fields and hedgerows, the great public accepts the facts as placidly as the ignorant victims. If we dwell on the children, it is but that their tenderness makes first call on our consideration, but we do not forget the effects on their parents. The well-to-do flee to the outskirts: for themselves and their young they

look to the hills whence cometh their strength: they claim the marvels of the spring, the up-springing of the daffodils and the bursting of the may blossom, the iris and the lilac for perennial refreshment. These citizens take the air with natural relish: for them the miracle of osmosis is joy unsullied—whilst, that is, they can stay in the homes they have chosen. But if work calls them to an industrial centre, then they too are conscious of the strain: they leave the brilliance of the country skies to blink under a cloudy noon, and in the dusty, frowsy streets of the poisoned city, they work against the grain, their jangled nerves awaiting the hour of release when they can breathe again an air that brings refreshment and relieves their tension.

Penal Servitude for Women.

What folly is it that destroys our natural habitat? Why should we erect the pall under which we daily walk to our own funerals? Surely it is as mad a procedure as ever Bedlam could conceive. There are cities abroad of size equal to any we know in which gardens and squares and gay flowering plants encourage beauty as the proper setting of industrial work—but we seem in England to regard the worker as specially subject to the curse of exile from Eden. Alliance with the angels is all to the good of course, but it is not recorded in Genesis that the flaming sword emitted a poisonous smoke that destroyed vegetable life on both sides of the barrier. It is not recorded either that the banished Eve had to spend her time alike in maintaining the flame of that sword and in cleaning up the débris of its destructive force. No: the poet's vision electrified the issue. It must have been the serpent who taught us to queer our own pitch and take pride therein. At great labour, Lord Newton's Committee have given us statistics which in "The Black Smoke Tax" pamphlet we can read for ourselves: the dreadful cost, the years of hard labour we impose on ourselves are surely an index of the low degree of our civilization which is little above that of a century ago, when lives were of less account than pocket handkerchiefs. We once complacently and smugly hanged for petty thefts: we still condemn to the torture of Sisyphus thousands of women whose sole crime is the desire to have spotless homes in a region of defiling smoke. The gates of their Bridewells are held fast by the twin warders of Work and Poverty: they must have easy access to the jobs by which they are sustained: they cannot afford either time or money to follow their employers far afield.

HOW THE CITIZEN TAKES THE AIR.

The Soul versus the Slum.

One of the most serious effects of this constant pre-occupation with the problem of dirt engendered by the stupid and wasteful use of coal is the dragging-down of the human spirit to the element it works in. St. Paul was conscious of the cramping effect of the flesh even in the sunlit orient. "Who shall deliver me from the body of this death?" he cried. But when to the common physical limitations, we attach the dreary necessities of endless scrubbing and cleaning of person, house, clothing, children, what chance is given for the spirit to lift its head and breathe its native quantum of light and inspiration? It speaks volumes for the sheer quality of spiritual endowment, that sweetness and charm, gaiety and kindness, survive at all amidst the squalor that prevails in the depths of big industrial centres, but is it fair to quarrel with the absence of these qualities, or to marvel that artificial stimulus is sought when natural means of expansion are wanting? I trow not. The effect of smoke cannot, of course, be completely dissociated from the overcrowding, the wretched housing entailed by ill-considered industrial development, the evils of which are exaggerated by the foul discharges of chimneys both industrial and domestic. But no matter how grandiose the schemes of rehousing—no matter how far the trams enable the workmen to be transplanted, so long as the burning of raw coal is permitted, so long will the evil of unnecessary labour and the creation of slum areas persist. For slums are made in the mind, and the mind can be slowly sapped till it fails to realize any possibility different from its normal filthy outlook. When I was living in the Midlands with a bright and beautiful garden, I once visited friends resident near the centre of Leeds, in a fine old house only recently surrounded by the pressure of urban development on the city's outskirts. They asked me to admire their winter aconites. I looked for them at first in vain—so subdued were their smutty faces as compared with the brilliant sheen and bright green collars of those in my own garden. My friend had become acclimatized to the grey atmosphere surrounding her, and when she took the air, she had learnt to ignore what else she was inhaling, and now her standards had become vitiated as a result.

Of course, the degradation of the human spirit is no new thing: there have been hewers of wood and drawers of water since wood and water were needed, but there has never been a time when we could less afford to keep any section of the community permanently in mean and degrading conditions. Such education as is possible is at least sufficient to arouse

odious comparisons, and who can foretell the results? Only by developing and fostering high quality, self-respect, and the love of beauty in every stratum of our society can we guarantee the permanence of these standards amidst whatever changes time may breed.

New Grates in Old Houses.

From the detailed housing reports recently published ("Times" 22/8/33, etc.), it is clear that the efforts made by the big cities are far short of the necessity. For the housing specialist the house is the important element, and no one wishes to minimize the need of change. But since the task of, e.g., replacing the 70,000 back-to-back dwellings of Leeds is one of many years, it should at least be possible to ensure that the absence of through ventilation is compensated to some extent by the purification of such air as can penetrate these frowsty quarters. This might be done either by the modification of the grates, the provision of gas or electric fires, or the insistence on the use of fuel other than bituminous coal in the city with properly organised stoking in the mills and factories. We were informed by the Chairman of the South Metropolitan Gas Company the other day that a large proportion of the consumers of their low temperature fuel were among the less affluent sections of the community, so that the step suggested would probably not meet with any hard and fast objection, if the necessary legislation be obtained.

The Social Effect of Air Pollution.

With our special object in view, it is necessary that we should dwell on one element of the case although other factors are not forgotten, but while it is not pretended that smokeless lands are free from crime or that there is no misery where the sun has free access, it is urged that the pollution of the air kills or spoils the child: that its effect in mental or nervous irritation and depression is contributory to more social trouble than has ever been analysed: it gives a squalidity to poverty which is unknown in rural areas: and saps native buoyancy and resilience at the heart. I have sometimes thought that much of the proverbial good cheer of the British fighting man amongst even the foul conditions of the Flanders front was due to the fact that despite the guns and even the occasional poison gas, he did have weeks of sojourn in camp or behind the front in rural England or smokeless France, which afforded an escape from the sordid conditions of his native surroundings. A thoughtful letter quoted with approval by Dr. Saleeby suggests that "reflex stimulation through the nervous system may turn out to be one of the most powerful modes

HOW THE CITIZEN TAKES THE AIR.

of action of sunlight and fresh air." This accords with popular belief and practice where means permit. Everyone knows the beneficial effect of a change of air when the urban patient has exhausted the medical resources of his local G.P.

No reference to the psychological effect of smoke could be considered complete which ignored its effect on people like the members of this Society. A smoke abatement committee was established in 1881: for upwards of 50 years propaganda on the subject has been considered, and whilst intelligence is absorbed with one problem, it cannot give attention elsewhere. It seems to a person capable of considering humanity at its high-water mark deplorable that so much effort, so much time and labour should have to be expended to remove an evil of such obvious and widespread dimensions. Our President's address has dealt in detail with the researches and examinations made in various areas: the complicated necessity of Regional Committees, the ponderous deliberations, the slowness of action, the meagre results, all illustrate the clogging effect of the black element they are concerned with. Meanwhile, new centres of pollution are continually being started. My main road to the neighbouring town $2\frac{3}{4}$ miles away has one factory set in a wooded hollow in a particularly charming valley. I hardly ever pass it, but I am vexed—nay, appalled—by the banner of black smoke which trails from its one tall chimney. It is a cheese factory, manufacturing cream cheeses for the nation. We should expect it to inherit the old-time attributes of the farm dairy—spotless cleanliness and sweet unsullied air,—but this plume of filthy smoke, flaunting its industrial pride across the face of the heavens, and defiling with its solid contents the lovely verdure below, epitomizes the relation of industrial development to the land on which it battens. So a modern Pluto invades again the flowery meads of Dis, and Persephone, though forewarned, is still helpless.

Smoke Versus Architecture.

One evil effect of our grimy atmosphere is the screen it imposes on architecture. We note our new buildings with acute interest. The citizen taking the air pauses to watch the workmen on their perilous tasks as the tall girders and fresh stone and concrete find their places. The fine cleanliness of the completed building arrests his eye constantly at first, but with the passage of the months, the sharp angles, the bright lines, the decoration, all merge into a blackened mass hardly to be distinguished from its gloomy neighbours save by the advertisements bespattered over it, which are necessary to establish its identity. The building has taken the

air, and the air has taken it and enfolded it in its carboniferous and sulphurous encrustations, and for the citizen, as an aesthetic composition, it has ceased to exist. The architect's name is of no moment—he has merely blocked out a hive for industry—and the thought and skill and individuality pressed into action go for nought. Manchester Town Hall is a striking example. When first erected, its creamy tower was a beautiful landmark from the surrounding hill country. What inspiration does it now suggest to anyone? A few years ago, we were startled to find when the inner corridors were cleaned, that the ceilings and columns were pleasingly set off with designs in the parti-coloured brick and stone of their construction. It was a complete revelation to every citizen of this generation. The immediate result was a sense of uplift, of awakened interest as soon as one entered the building: what is now happening to that interior, I know not—but Sheffield and Leeds, who have recently acquired such splendid civic buildings, should at least sit up and take notice. I understand that there has been some discussion as to whether we should have this meeting in this Memorial Hall on a Sunday. Personally I cannot think of any subject which could be more appropriate to a casket of memories of this kind. We are here to protect the beauties of this hall and to remind Sheffield that to the soldiers, the heroes, we promised a land fit for their descendants to live in. We want this shrine to remain a beautiful building so that their memories may be fitly housed for ever.

Here we are in the midst of a most beautiful building, and I noticed on entering that the buttresses outside already bear marks of the grime of this city. It is of no use for any of the officers of this city talking about a reduction in smoke so long as we see these horrible marks on buildings that are absolutely fresh. They are sufficient object lessons. One wonders how long the gorgeous colourings introduced by Mr. Vincent Harris into this unique hall will maintain their brilliance.

Aspiration, Inspiration, Respiration.

That a generation, ready to protest against the unmitigated gloom to which we and our forebears have condemned city life, is arising, is evidenced by the army of "hikers" which on every high day and holiday throngs the railway stations bent on taking the air in unsullied purity. We can but applaud their good taste—whilst regretting that their abounding energies should be forced thereby to turn their backs on their homes: that their daily surroundings should give no scope for the love of natural beauty which is their birthright. In this

city (Sheffield) there is, I believe, hardly a point from which some vision of green hills is not still visible—it is a place where at least every prospect pleases, even if man has not at present risen beyond Bishop Heber's opinion of him. There is nothing wrong with our climate—despite the fogs and mists traditionally associated with our island; the contours and colours of our glorious hills and moorlands in these Northern counties are unsurpassed anywhere in the wide world. Travellers extol the brilliance of our gorse and heather-clothed heights, and the mere domiciling of workers could not have accounted for the horrors of South Lancashire and Yorkshire and North Staffordshire. What has worked havoc with natural beauty is what has worked havoc with our lungs, so that even our hymns of praise to the Creator are marred by such a hawking and coughing and choking that worship is interrupted, and the eloquence of our parsons stemmed. Who can let himself go with the wings of the spirit outspread when his sonority has to compete with the noisy discomfort of bronchial sufferers. Who of us has not known the acute misery of struggling to swallow a cough to save our neighbours from the distraction which entirely prevented us from profiting by a speaker's wit or wisdom.

Smoke is not solely responsible for these respiratory troubles, of course. This can be granted without in the least weakening our case against it. For if climatic conditions naturally conduce to any physical weakness, so much the more foolish is it to strengthen their attack by a chemical pollution which can be completely avoided. Analysis shows moreover, that whatever the natural tendency to fogs, their number is increased and their risks intensified by admixture with the effluvia of our chimneys.

Nervous Reactions and Social Morality.

Quite apart from the low pressure incidence of fogs and mists is the constant reduction in the active force of sunlight through man-created screens. The Halifax figures quoted by the President indicate the extent of this evil. It is impossible to assess with any exactitude the effect of such artificial gloom. As a young Civil Servant, I was employed in various Departments, in some of which one hardly saw any natural light from October till March, save at the week-ends. This induced in myself and my colleagues a nervous irritability which was not infrequently manifested in a certain fratchiness of temper, a querulous manner, a tendency to find fault quite alien to normal life in bright and cheerful surroundings. One observes the same sort of thing in the back streets of our smoky towns:

one has only to listen to the exasperated tones of harassed parents to realize the toll on nerves and temper exacted by gloom and the endless and futile toil to counteract it. In that wonderful chronicle of Kristin Lavransdatter, the authoress records with convincing detail the irritating effect of the clouds of smoke driven about the dwelling before the days of chimneys—so that faces were begrimed and eyelids reddened by its filth and astringency. Constructional changes may have freed to some extent the rooms, but in the streets, humanity is still tarred with the same old brush.

From the start to the extinction of a coal fire, there is constant need of attention—of stoking and poking, of the getting of fuel and the raising of dust—all of which are the fretting warp through which the woof of comfort is inter-twined. The condition of bookshelves in a fire-warmed room indicates how subtle is the infiltration of dirt from this source, and this affecting as it does every article in the room, adds enormously to the demands on the time and labour of women.

Even a special pleader should exercise some caution, but it would be curiously interesting to know the effect that smoke as an irritant has on social morality. A smoky chimney and a bad tempered wife—a husband driven to the dogs or drink—the disruption of families due to the woman losing all her youthful charm in the dusty drudgery of daily life . . . ! But I restrain such curiosity, knowing that the millennium will not be achieved, even if our cities become bathed in fragrance and limpid light. I remember Breslau in the summer of 1922, pervaded by the scent of lime trees: its broad streets were avenues of beauty, the railway station opened on a great space filled with beds of roses. Sheffield might emulate that attractiveness, and would be far nearer a Paradise than that German city is to-day.

As a witty writer recently remarked "A rut is not a gold mine and never will be," and almost more important than the attainment of our goal is the realization of unnecessary addiction to ruts. The provision of new ways for daily life is one means of promoting perpetual youth. We want our people to accept nothing as necessary which thwarts life: everything as necessary which conduces to the general well-being. When our citizens take the air, we want them to enjoy clean and pleasant streets in which trees and flowering plants will freely flourish: we want them to walk by buildings which nobly represent the thoughtful conceptions of architects revealed in the best light and maintaining to the end a face, however scarred by wind and weather, with features unsullied and undimmed by sooty incrustations. We want our citizens to

HOW THE CITIZEN TAKES THE AIR.

take the air rejoicing in the fact of citizenship, in the pride of their own contribution to fine surroundings by higher standards and cleaner living. "We are dogged by inertia" says Bergson. We must bestir our consciousness and take hold of the machinery of our life if we want to direct it in lovely ways. Costly it may be, but it is worth while. And right along the line there are economies—amongst others, the proper use of coal, the extraction of maximum power, and the effective marketing of the bye products of its distillation. The nation is becoming alive to the importance of home produced oil, and it may well be that the effective demand for this will enable the cost of smokeless fuel to be reduced to meet the paying capacity of the public at large. In that case, the transformation we dream of will be rapidly effected. The British citizen's compromising spirit will be happily accommodated. He will retain his glowing hearth: his pocket will be unconscious of the strain: he will be able, when taking the air, to preen his moral plumage proudly, conscious of having performed a civic duty, and in a short time, he will disbelieve that the filthy surroundings which he now complacently accepts have ever existed.

Dr. Rennie then called upon Mr. Charles Gandy to read the paper written by Mr. H. C. Clayton and himself.

THE COMBATING OF DOMESTIC SMOKE IN INDUSTRIAL AREAS.

By R. H. CLAYTON, M.Sc., M.Inst. Gas E., and
CHARLES GANDY.

The problem of smoke abatement has been dealt with in so many papers that one might hesitate to begin another, were it not that the writers of this paper are convinced that a stage has now been reached in the Smoke Abatement Campaign when the very real advances already made must be consolidated and given practical application, if we are to enlist further public interest in the matter. Most of the work of this Society in the past has been educational, dealing more with the causes and effects of smoke than with the practical steps necessary to hasten a solution of the problem. Thanks largely to such work the imperative necessity for the elimination of the pollution of the air by smoke is now accepted by all thinking people, and no new arguments are required to convince those who are willing to give the matter their attention. It is the unthinking man, the man in the street, that is the problem. He can only be finally won over not by our arguments, but by our achievements. When he can *see* progress, he will begin to take notice. True, he no longer looks upon the smoke abater as a harmless fanatic. If it is put to him he will say almost invariably "something ought to be done." He pre-supposes that there is some public authority, some government or corporation department, having that duty, just as he takes it for granted a public authority will see to it that he has a perfect supply of clean water and unadulterated food, that the sewage from his home and those of his neighbours is properly disposed of, that the streets are maintained and lighted and traffic controlled, and that the hundred-and-one other things which make life in a city possible are duly attended to. Putting it briefly, we suggest that once again the man in the street is right. The responsibility must be made a public responsibility. We have referred to the mass of work done and papers written on air pollution and its remedies, but when one looks for organised effort to utilize such material to the full, one is faced with the fact that no co-ordinated effort appears to exist. Our National Smoke Abatement Society has been a small voice crying till recently in an apparent

THE COMBATING OF DOMESTIC SMOKE.

wilderness of inertia and ignorance. It is only since 1930 that Municipalities have accorded that civic acknowledgment of our voluntary work which it is now our pleasure to receive in this city. We suggest that the time has come for them to go further, and to give the work of smoke prevention its rightful place in their own activities. If they do so, they may rest assured that the public will cordially approve their courage and enterprise.

There is, in the first place, much that can be done through existing channels of municipal life. Education departments, for instance, might help.

The address by Dr. H. A. Des Voeux, and the papers read by Alderman Adams, at the Meeting held in Newcastle last year, and by Mrs. Jast this morning, have developed the psychological aspect; and if, in this direction, we could interest the coming generation, great progress could be made by creating in them a responsive and therefore a co-operative frame of mind. If only the city dweller could be brought up to notice and to think about domestic smoke and its evil effects it would be of immense value in getting willing co-operation. An unresponsive and passive resister is a most difficult person to deal with.

Whilst we hesitate to suggest the introduction of fresh matter in an already overcrowded school curriculum, yet if the broad view be taken that the object of education is to raise the standard of living both mentally and physically, and add to the general happiness of life, then we will agree that a proper system of education must include instruction designed to interest young people in the improvement of the cities and towns where their lives are to be spent, and which are our common homes, and to teach them that they have a duty to their neighbours in this matter of cleanliness. They could be shewn by wall charts or photographs something of the evils and cost of air pollution, and the contrast between some of our industrial neighbourhoods and others in this country and abroad which are more fortunate. And they could be taught that all this can with their help be changed for the better, now that smokeless methods are becoming more readily available. As it is, we teach art and nature studies in places where any architectural beauty there may be is smothered in dirt, and nature coated with soot and starved of light can barely exist.

What we want to get into the citizen's mind is well stated in a recent competition in the "Manchester Guardian" for an inscription on a sundial which if it were taken to heart should surely awaken the most inveterate coal burner to his duty:—

THE COMBATING OF DOMESTIC SMOKE.

Out Coal! Remove my handicap!
Clear your skies of smoke!
My dial will tell the time mayhap
When sense comes to you folk.
A Sundial need not always be
Just a curiosity.

Again, in the matter of housing and new buildings, and the preservation of existing buildings, Municipal Authorities can set a valuable example.

Housing Conditions.

The urge for better living conditions has shewn itself since the war in the mass production of small houses away from the densest smoke area, but let us not forget that too often these building developments are shutting out more and more the city dweller from the country and so making worse and worse *his* living conditions. The betterment of the few may well reflect adversely on the many, and the subject of Smoke Abatement thus becomes of even greater importance to the mass of the people, who will continue to remain in city dwellings, some from preference, the majority from necessity, and to all who for one reason or another must spend their daylight hours within the city area.

The smoke evil is undoubtedly linked up with the housing problem and has, maybe unwittingly, influenced the policy adopted in regard to slum areas. Dictionaries give the following definition of a slum—"a dirty back street of a city." Here we have "dirt" and "back street" emphasized, signifying black and gloomy conditions which are products of city smoke. There is no mention in the definitions of "overcrowding." Similar small houses in the country, the country cottages which we love to look at, are probably no more sanitary, no larger for their occupants, but they have pure air and light.

We cannot be too often reminded that light is essential to life. There is a mysterious saying that Light is Life. Certainly, healthy people abhor unnatural darkness, as they abhor dirt.

To those who have visited great cities abroad and are acquainted with their housing conditions the absence of the domestic smoke plague, the concomitant economies in the cost of living and the greater cleanliness and brightness of city life in such cities as compared with our own are food for reflection. We are still a very insular nation, and we are afraid few really appreciate, or are in fact able to visualise, cities without smoke, nor what our own cities would look like

THE COMBATING OF DOMESTIC SMOKE.

if there had been a constantly clean atmosphere. Under such conditions our cities would be clean and full of colour; and one can imagine the faces of the inhabitants reflecting the beauty of their surroundings.

This is no idle statement, as those who have lived abroad and return to our cities note a more gloomy expression on the face of the city dweller. Surely the time has for ever gone by when any city can be proud of its smoke begrimed buildings. We are becoming an open air people, and the boast of a modern city will be the purity of its air, and the resultant beauty of its homes and civic buildings as well as of their surroundings. Here, again, is a line of practical development which ought to be followed if we are to win over the mass of the people. The man in the street will always be interested by visible signs of progress, such as the new civic buildings in Sheffield and Leeds, the great new Central Library in Manchester, and other architectural changes shewing up by contrast the darkness and dirtiness of our old surroundings.

Would it not be possible for Local Authorities to see that these new buildings are kept clean. Throughout the greater part of the year water costs nothing and labour could be profitably employed. Again, in most ancient cities there are certain buildings, a Cathedral or Guild Hall, for instance, which though not public property could be scheduled as monuments of public interest, and the Local Authority could intervene to help in the cleaning and preservation of such buildings to fit them for their place in the city of the future.

The nation has now commenced the long overdue clearance of slum areas, under what is known as the five year plan. It is, therefore, an opportune time to consider how best to prevent the new housing from again becoming an eyesore, depressing the tone of its inhabitants, as it certainly will if the smoke polluted air continues to play on the new surfaces.

But let us come to our main point, the necessity for further special organization, national and local, if final victory against smoke is to be won.

Municipal Organization.

To our knowledge there is no city having a Department solely concerned with air pollution. One cannot consider the good but restricted work of any Sanitary Department, however efficient it may be, as coming under this heading. The work of the Sanitary Department is concerned with air pollution by industrial smoke. Such pollution in Manchester and other commercial cities may be only a small fraction of the total pollution. In Sheffield, with its special industries,

THE COMBATING OF DOMESTIC SMOKE.

industrial smoke may bulk more largely in the total, but if in fact there are places where the nature of the principal industries concerned makes industrial smoke almost unavoidable, it is more important in such places to take all possible steps to reduce avoidable domestic smoke. The work of a statutory Regional Committee under S.6 of the Public Health (Smoke Abatement) Act 1926 is also practically confined to industrial smoke and cannot be on the scale we contemplate. (The total expenditure of the Sheffield and Rotherham Committee for 1932 amounted to only £1,181). What we should like to see in relation to local Government, is the creation of a new Committee or Sub-committee co-ordinate with existing Committees and having an equal claim on public funds, to which would be assigned the sole duty of developing the methods and building up the organization necessary for dealing with the smoke nuisance caused by domestic smoke, precisely as there there is a committee responsible for dealing with water supply, sewage disposal, and other matters. It may be that further statutory powers will be necessary, but already a sufficient statutory power to enable the setting up of such a Committee and the doing of valuable work exists under S.10 of the Act last referred to, which reads, "a Local Authority may undertake or may combine with other Local Authorities in undertaking investigations and researches into problems relating to atmospheric pollution and the abatement of smoke nuisances, and may contribute towards the cost of similar investigations and researches undertaken by other bodies or persons." If the powers of that section are used to the full a sufficient beginning could be made in preparing the campaign against the domestic smoke nuisance. The fact that the Government has recognized the value of such work by the creation of the Fuel Research Board, and by subscribing to the Atmospheric Pollution Committee, justifies the spending of Local or District Funds to utilize and find practical application for such research work from all sources. District organizations could be linked up with the Fuel Research Board, which is at present engaged on problems connected with the avoidance of air pollution from domestic dwellings, and also of ventilation, a question peculiar to England with its open fires, as one finds when abroad, where the heating systems used are often trying to English people.

Types of Pollution.

The efforts of previous generations towards better sanitation have been concentrated on the two elements of earth and

THE COMBATING OF DOMESTIC SMOKE.

water. The present generation is beginning to concentrate on the elements of fire and air. It is indeed remarkable that while there are highly organized Departments to deal with two of the waste products from domestic dwellings, we refer to solid refuse and the liquid effluent or sewage, it is only the third or gaseous effluent which has no specific organization to deal with it. If some giant hand could lay all our buildings down on their sides, so that the smoke emitted blew out into the streets instead of the air above us, whole cities would soon be up in arms against it. As it is the winds from heaven do what they can, but where the inhabited area stretches many miles on every side, they often only succeed in disposing of our smoke by depositing it on more or less distant neighbours.

Let us by way of comparison consider what has happened in the organizations, now necessitating large expenditure on capital and operating costs, which have been built up to deal with liquid and solid refuse. In Manchester the capital involved merely in the purification of the sewage before it enters the Ship Canal is according to the accounts over £1,000,000 and the yearly working cost (exclusive of interest and sinking fund) over £60,000. The figure for Sheffield under the heading of Sewage Disposal is £98,000 less £20,000 Government grant giving £78,000, equal to a rate of 7.42d. in the pound. All inland cities and towns have heavy expenses in this item of sewage purification which, as all will admit, is justified in the avoidance of epidemics and the obtaining of a greater cleanliness of the rivers. The officials in these existing Departments, linked up as they are one city with another, in scientific work of common interest, are always steadily improving the nations position in sanitary matters. There is in fact a web of communication by which the greater centres keep in touch and radiate progress to the smaller towns whose resources do not justify expensive research nor experimental capital outlay.

The annual cost of sewage purification in the whole country can be figured in millions. It may be noted "en passant" that we do not drink the sewage so carefully purified, but that each adult person does breathe in daily some 35lbs. of air so thoughtlessly polluted.

There may be little to comment on in regard to the collection and disposal of the solid refuse of cities, but in this direction the organized application of known preventative measures has resulted in the almost total elimination of the fly plague in the summer months. This blessing is largely due to the practical use of the scientific work carried out in

THE COMBATING OF DOMESTIC SMOKE.

relation to the breeding conditions necessary to fly life. It was determined by scientific investigations how long it takes for the eggs to hatch and pass through the larva and pupa stages, and if the refuse be removed before the fly emerges the unpleasant presence of this pest can be kept within reasonable limits.

Further comparison may be made with other existing civic activities and the expenses they involve. The necessary pure water supply involves everywhere immense capital expenditure and supervision by a scientific organization. In regard to food products the control of the milk supply is an example; for the year ending March 1932 it cost Manchester over £4,700. During last year Sheffield expended over £76,900 in the treatment of tuberculosis, a darkness disease partly at least attributable to smoky conditions. Or let us read from the information at the back of Rate Demand Notes in Manchester. Under the heading "Public Health" we find a rate of 4/10d., representing more than a quarter of Manchester's total expenditure, divided between Refuse collecting and disposal; Parks and Recreation Grounds, Hospital and Maternity; Child Welfare and Tuberculosis; Sewage and Sewage Treatment; Baths and Wash Houses; Inspection of Factories, Food, Animals and Sanitation. Never a decimal of a penny goes to air purification, unless we count the comparatively trifling expense incurred by the Medical Officer's Staff in the control of Factory Chimneys by observation, and in the case of Manchester a comparatively generous subscription to this Society.

Comparing the accepted state of affairs in the cases of liquid and solid pollution and other matters, in which public activity and expenditure is taken for granted, the apathetic attitude towards air pollution is indeed difficult to understand. It requires little power of observation to realize that almost every other class of work for the public welfare suffers, in one way or another, from this plague of smoke and dirt which overpowers our cities. To use a figure from the parable, while city Councillors, public servants, and others engaged in every type of welfare work are sowing good seed, but while men sleep the enemy comes by night, and indeed by day also, and sows tares.

Surely it is possible to organize in regard to smoke prevention a unified effort on lines similar to those used in other matters of sanitation and to lift the movement above the restricted efforts of commercial interests, which are always subject to the commercial law of making a cash profit (rather

THE COMBATING OF DOMESTIC SMOKE.

than a profit in common welfare) on the capital involved. "Smoke Abatement" as a slogan for sales of, say, Gas Coke, and Electricity, is of commercial value. It is the same as "Eat more fruit" etc., and no doubt the great mass of the citizens place it in the same category. Does not the fact that smoke pollution costs the inhabitants of cities at least £1 per head, and the latest estimate gives £2 per head, per annum justify such a specific organization. In pre-war days the country may have been able to afford this national waste. But world conditions, and our own with them, have changed. We have, for instance, to compete with growing industries in better conditions abroad. The wages of our workers are greatly reduced in real value owing to the continual fight against grime and dirt, and there is also a constant necessity to purchase artificial pleasure to counteract the depressing conditions of their environment. The standard of living is therefore not as high as it would be under cleaner conditions of city life. Bad living conditions breed, and justifiably so, labour unrest. And buyers from abroad will not be attracted to our dirty and gloomy centres when similar goods can be purchased in brighter surroundings elsewhere.

To sum up, we have asked Local Authorities to co-operate more fully than they have hitherto done in the work of the prevention of smoke and the cleansing of our cities from its effects both in their existing Departments, e.g. those concerned with Education and Housing, but more especially by the setting up of special Committees and Departments to devote their whole attention to the problem. If you ask what exactly is to be done by such Committees and Departments when formed we reply by referring you to the history of every other Department of civic activity. It is a history of the development of manifold activities in the determination to achieve the purpose which led to their formation. Clearly it would be the duty of such a Department, and of the several Departments in various areas working in co-operation one with the other, to investigate and obtain the fullest possible information in regard to the sources of smoke pollution in their respective areas, and to use, without resource to further legislation, every means to extend the many smokeless heating devices and methods of smoke prevention which are at present available in this country and abroad, and those which are being evolved in the course of experimental work, and all types of smokeless fuels. The publication of such investigations and researches will keep the ideal of smokelessness constantly before the public. In connection with the production of solid smokeless fuels, it is

THE COMBATING OF DOMESTIC SMOKE.

gratifying to note the great progress made during the last decade. Coke, the former Cinderella of the Gas Industry's by-products, is now receiving that attention necessary to make it more fully suitable for the domestic grate. Work done in recent years on blending coals before carbonization offers great possibilities in producing a product more nearly resembling house coal in its free burning qualities. The production of a suitable smokeless fuel from Coke Oven plants is being studied and offers an attractive field for the various plants at the Collieries.

Artisans' Dwellings.

At present the main sources of City smoke are commercial buildings and artisans dwellings. The former are usually within a comparatively small area, and if a civic policy were clearly expressed, we feel sure that the commercial community, which is beginning to see the advertising value and other advantages of clean and colourful buildings, would be only too ready to co-operate, as also would the architects and others concerned in the erection of new buildings. With the assistance of gas and electricity concerns their products and other smokeless fuels might be made cheaper and more popular in central areas. The artisan's home is a more difficult problem, since property owners are naturally disinclined to spend money and the artisan is not in a position to instal new fires or pay for expensive heat units. In this connection, however, one must not overlook the fact that within recent years cities and towns have, at someone's expense, converted the old privy dry pail system to the water carriage system in the interests of a better city life. The contribution of the Sheffield Corporation to the cost of such conversions in the year ending March, 1933, came to the large sum of over £9,150. If we consider the enormous sums annually expensed in other matters under the heading of "Public Health," we shall not be afraid of the application of a little public money to assist in making the homes of working people cleaner and more free from the smoke and dirt which has been so largely responsible for the creation of the present slum areas and the costly problem they present. We wish to stress that we have throughout been most concerned with those who must live and work within our cities. We are less concerned with the condition of the richer people, or with the comparatively small number living in subsidized houses away from the denser smoke areas. Housing Schemes and Developments are yearly stealing the country away from the less fortunate majority and making it

THE COMBATING OF DOMESTIC SMOKE.

all the more necessary to view the future from the city dweller's point of view. If the more fortunate people living in subsidized houses benefit by the expenditure of Government and public funds to the extent of 4/- to 5/- per week in the reduction of house rent, and also the increased cost of extended public services thrown on to the rates, a very high oncost never shown in housing schemes, there is a just claim for public funds to better the conditions of the less fortunate citizens who must remain in the smoke laden air of the city itself.

DISCUSSION ON THE TWO PAPERS.

ALDERMAN WILL MELLAND (Chairman, National Smoke Abatement Society) said that the paper read by Messrs. Clayton and Gandy offered many valuable suggestions, and he agreed with the proposal that sub-committees should be set up to consider smoke abatement questions. Whether these bodies should be sub-committees of the Public Health Committee or separate committees was a further question, and he was of the opinion that they should be sub-committees of the Public Health Committee as they would then have funds available for their work out of the general Public Health funds.

He also suggested that these committees should co-opt outside members who were not members of the Council. It was no new thing to have such outside assistance, and in his own city this was already done in the case of the Public Health, Education, and Art Galleries Committees. Many excellent civic improvements had been started with private initiative and were ultimately taken over by the local authority.

BAILIE MUNRO (Glasgow) said that he had been interested to hear the proposals put forward in the paper by Messrs. Clayton and Gandy, but the Conference should know that such methods had been anticipated in Glasgow, where there had been a special committee on the Corporation for twenty years. He urged the greater use of exhibitions for creating wider public interest in the subject.

ALDERMAN DAVID ADAMS (Newcastle-upon-Tyne) suggested that a copy of Mrs. Jast's paper should be sent to every municipality in the Kingdom. The Committee advocated in the paper by Messrs. Clayton and Gandy was a most admirable suggestion.

Mr. G. S. FRANCIS (British Electrical Development Association) stated that among the various agencies that were being employed to reduce or eliminate the smoke nuisance the growing use of electricity would be certain to receive increasing attention as time went on. Already during the past few years the amount of replacement of steam drive by electric drive had either abolished or rendered unnecessary the use of 20,000 to 30,000 factory chimneys while the

THE COMBATING OF DOMESTIC SMOKE.

steady extension of electrical methods into various heat processes also tended in the same direction. Within the domestic field the rapid extension of electricity for purposes of cooking, water-heating and occasional heating had made possible the evolution of a new type of house which required only one chimney pot to accommodate the fuel fire used for continuous heating of the living room during the winter. These one-fire houses were steadily growing in number and as they grew the smoke trouble receded. Mr. Francis urged, in conclusion, that those who desired to advance the social amenities of the community should be a bit less terrified of finance. Many delegates had indicated desirable reforms that were held up only for lack of money. The time was well overdue for a change in our opinions about the nature and use of money. Money was no longer a rare and precious metal that must be conserved. The nature and technique of money had changed greatly during recent years. To-day it was in the main merely a book-keeping system recording the financial values of things and events. If, therefore, we possessed the material means and the technical skill to carry out any socially necessary and worthy task we ought not to allow ourselves to be frightened by figures in books, but to bend our minds to the task of trying to modify the financial mechanism so as to release our great reserves of material and skill for effective work.

COUNCILLOR MISS M. M. F. CLARKE (Adwick-le-Street U.D.C.) said that, coming from a colliery district, she had brought the question of smoke abatement before the local Council, of which she was a member, and had asked them to exercise their powers under the 1926 Act to compel a local colliery company to discontinue the volumes of smoke that emanated from their chimneys. She had urged that something be done to end the contamination and nuisance, and the Council, which is composed of Labour men, were on the whole fairly sympathetic, but one member rather forcibly reminded her that it meant interfering with the miners' livelihood. With that fear, having regard to the present economic conditions in the mining areas, she could sympathise. After further discussion a resolution had been carried to the effect that the Sanitary Inspector should take up the matter with the company, and since that had been done things had greatly improved, the Inspector taking day by day observations.

Miss Clarke pointed out the extra labour and cost of cleaning materials involved, so far as it affected the house and wife, and further, as a woman, she was not afraid of men, but men were men, and on many local authorities there were representatives who were directly or indirectly interested in industries, and were not at all keen to force the issue on this point, well knowing that it possibly meant the introduction of new plant—which no doubt they would put in if the Government subsidized them as to cost.

As a woman she would endeavour to arouse the women on the

THE COMBATING OF DOMESTIC SMOKE.

subject, feeling confident that once they understood the seriousness of the menace there would be a rising up, and a demand, that the local authorities should do their duty, irrespective of anybody's criticism. She suggested that the Society should get in touch with women's organizations and offer lectures on the subject. Women who understood the contamination and injury to health involved in neglecting to force home these facts in the proper quarter would not rest until the pollution of the air was a thing of the past. Life came before wealth—although she would also like a little of the wealth.

Mr. S. R. DANIELS asked whether we had got to the point at which the domestic coal-user of small means could be told: "There are smokeless fuels which you can burn instead of coal without increase of cost." If not, it did not seem to him that much progress could be made with the domestic side of the problem until a reduction in the price of these fuels could be secured.

COUNCILLOR W. ASBURY (Sheffield, Rotherham, and District Smoke Abatement Committee) said that all the houses built in Sheffield since the war were burning raw coal. It was not enough merely to arouse public opinion, but action had to be taken to back up such opinion, and to do this statutory powers were necessary.

Mr. J. T. HAYNES (Gas Engineer and Manager, Rotherham) said that he had the honour of attending the conference as a visitor and did not claim to represent any authority or any vested interests. Although he held an official position with the Rotherham Corporation, he thought he was also the "man in the street" referred to by Mr. Daniels, and smoke abatement excited his keen interest.

He was not authorized to speak on behalf of the gas industry, but from his knowledge he could deny very definitely the suggestion of Alderman Adams that there was a "ring" in the gas industry to keep up the price of gas. Common sense indicated that with the keen competition from smokeless fuels, coke from coke ovens, and electricity, as well as of foreign oil, such a policy would be impossible. He had reason to know that in order to meet that competition the gas industry was making every effort to keep the price of gas as low as was economically possible.

He had been particularly interested in the previous day's discussion on the statutory position of smoke abatement, but he was forced to the opinion that the whole question centred on cost.

The manufacturer was generally well informed as to the technical progress in his own industry. His main concern was cost—cost of coal v. cost of smokeless fuel. In this connection it would seem that for many processes coke was unsuitable, coalite at present prices too expensive, and the use of gas and electricity depended on the price locally. Broadly speaking the manufacturer found a solution in Producer Gas, which he could control and which was smokeless.

THE COMBATING OF DOMESTIC SMOKE.

In the domestic field the householder had been educated up to the point where he appreciated the value of the cleanliness and comfort of gas and electricity, but so far he could not afford to use either except intermittently, and as a luxury.

One was tempted to echo Mr. Councillor Asbury's questions and ask whether municipalities were supplied on terms that would enable householders to use them continuously, all day and every day, like a coal fire? Why should not municipalities be prepared to assist householders to convert their fireplaces as they had been assisted in the conversion of privies—and medical opinion indicated that one was almost as necessary as the other.

Attention has been drawn to the Sheffield, Rotherham, and District Smoke Abatement Committee, and he would like to congratulate Sheffield on giving such a lead to the country. As he saw things, Rotherham had gone a step further. It treated smoke abatement not as an abstract ideal but as an integral part of a scheme for the improvement and development of the town. The Rotherham Corporation had recently decided to offer electricity for domestic heating and cooking at a flat rate of $\frac{1}{2}$ d. per unit, without any rateable value or other fixed charge. The Corporation was also experimenting with a two-part system for charging for gas, which enabled the smallest householder to have gas at 10d. per 1,000 cubic feet, and he knew of a number of houses which were run entirely on gas and electricity, with no coal used at all, and—this was an answer to Mr. Daniels—the householders were finding it cheaper than coal. One man had told him that he was saving 2/- per week, or at least he could spend 2/- per week more on food for his family, and if this was not saving he would like to know what was.

This was not a cut-throat competition between two Corporation departments, continued Mr. Haynes, and was not a blind reduction in the price of a public service without reference to its cost: it was a definite attack on the smoke nuisance. That was practical politics.

The Gas industry was handicapped by antiquated legislation—just as smoke abatement was—legislation passed at least a generation earlier than the Public Health Act which was said to limit smoke abatement efforts. Could not the Society pull its weight to have those old limitations removed? He was sure that as soon as gas obtained its full freedom much more might be done towards smoke abatement. The efforts made by Rotherham might well be considered. There had been much talk of forming more committees, advisory and statutory. What these committees were to do should also be considered. All knew what happened to unasked-for advice, while penalties only caused annoyance and opposition. There was a demand for leadership and he suggested that the Society might take a more active part in achieving practical results.

THE COMBATING OF DOMESTIC SMOKE.

Mrs. IDA M. COWLEY (Member) said that she was afraid that in the discussion one point was being overlooked. She did not think that smoke abatement was mainly a question of £ s. d., or even a technical matter. There was the usual bugbear of sentimentality to be taken into account. Whenever she tried to convert people and persuade them not to pour smoke into the air through their domestic chimneys, they always replied: "I love to see a coal fire burning; the chimney is such a marvellous ventilator, and I must have something to poke." So to get at these people, and in spite of what Councillor Asbury said, did mean large scale propaganda, particularly among women.

Mr. A. ARTHURS (Beautiful Oldham Society) said that this was his third conference, and that its spirit made him feel that there are some people interested in the question of air pollution.

He was afraid that, as a delegate of the Beautiful Oldham Society, he would go back to the inaction and "don't care" spirit that they always had in Oldham. He wanted to say, as a Trade Union official, that he did believe in classes for boiler firemen because every time he had the chance he told mill managers that an efficient fireman works for nothing compared with one who does not know his work. The efficient man saves more than his wage in the amount of coal that he saves.

He had thought many times that it was the employers who needed educating. In the cotton trade they could burn more than 74 tons of coal in a week, starting at 6-45 a.m. until 5-30 p.m. for five and a half days, and also working Sunday morning. For this they received only £2 19s. 5d.—or less than 1s. 1d. per hour.

He had found from time to time that if one of their members was away from work for any reason, managers did not send to the Trade Union for a man, nor did they send to the Labour Exchange, but put on a man from the yard.

The paper by Mr. Clayton and Mr. Gandy had spoken of high rates of pay to enable people to buy artificial pleasure, and he trusted that this would not be made an excuse for an attempt to reduce wages, which, in his opinion, were too low already.

ALDERMAN WRIGLEY (Oldham) replied to the points regarding Oldham that had been raised by Mr. Arthurs.

COUNTY COUNCILLOR G. A. GRIFFITHS (West Riding of Yorkshire C.C.) supported the statements made by Mr. Arthurs with regard to the payment and status of stokers.

Mr. R. H. CLAYTON, replying to the discussion, referred to the results of the co-ordinated work on the solution of the pollution problem of the streams by sewage effluent from cities and towns. He remembered the inauguration of the special department in Manchester and the appointment of Dr. Gilbert J. Fowler from the Manchester

THE COMBATING OF DOMESTIC SMOKE.

University to work on the small experimental bacteria beds at Davyhulme. The co-ordination of the Manchester results with those of other cities, in all processes of purification, had led to a result which was highly satisfactory. For this purpose public funds were used, and the expenditure was more than justified. The time taken to solve the problem had been little over thirty years. The field was now open for dealing on similar lines with air pollution, and taking advantage of modern scientific progress there was hope that solution of the latter problem could be accomplished even more rapidly than the other.

Following a Vote of Thanks to Dr. Rennie and to the authors of the papers, the Conference terminated.

List of Publications.

(All prices include postage. Reduced prices for quantities).

The Smoke Abatement Handbook. A recently published *vademecum* on all aspects of the smoke nuisance and its abatement. Contains authoritative articles, numerous statistics, and a variety of interesting facts. Indispensable to all who are concerned with the subject. 8vo. pp. 48. 6d, 5/- per dozen copies.

The Journal of the National Smoke Abatement Society. Published quarterly. Is not a record of proceedings but a magazine—the only one in the world—devoted to the problems of atmospheric pollution. Contains authoritative articles, notes on technical methods, news of activities of every kind, and in general keeps the reader up-to-date in every aspect of the subject. Per annum 2/6. Gratis to members.

Fumifugium ; or the Smoake of London Dissipated, by John Evelyn. This rare and fascinating book, first published in 1661 by command of Charles II., has just been republished by the Society with an introduction by Miss Rose Macaulay. It is illustrated with original wood engravings and a portrait of Evelyn. Paper covers 6d., cloth bound 1/6.

Home Fires Without Smoke. Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. 2/- and 3/6 (cloth).

Smoke and Fumes Nuisances from Road Vehicles. Technical and scientific aspects by Dr. J. S. Owens, A.M.Inst.C.E., M.I.Mech.E. ; and the legal position by R. P. Mahaffy, M.A. 8vo. pp. 16. 3d.

Smoke and Health. By Dr. J. S. Taylor, M.D., D.P.H., Assistant Medical Officer of Health, Manchester. 8vo. pp. 12. 2d.

Smoke Abatement in Salt Lake City, Utah. A full and illuminating report of the intensive and successful campaign in Salt Lake City. 8vo. pp. 43. 3d.

N.S.A.S. Annual Reports. Gratis, by post 1d.

Conference Reports and Proceedings :

Report of the 1924 Conference. Only a few copies of a valuable report. 21 papers in full. 8vo. pp. 308. 5/-.

Report of the 1926 Conference. 10 papers in full. 4to. pp. 98. 1/-.

Proceedings of the Newcastle Conference, 1932. Containing the Presidential address, papers by R. A. Mott, on "The Domestic Smoke Problem: the Possibilities of Coke Oven Fuel"; Alderman David Adams, on "The Psychological Effects of Smoke"; A. E. Crossley, on "The Human Element: A Factor in Smoke Abatement." With discussions. 8vo. pp. 63. 1/-.

A Paper by Sir Frank Baines. This valuable and comprehensive paper, which was read by Sir Frank Baines, K.C.V.O., C.B.E., F.R.I.B.A., at a meeting of the Society in the summer, is not only a survey of the effects of smoke upon buildings, but summarizes the conditions disclosed by various inquiries into the condition of the atmosphere over Great Britain. Ready shortly. Price: 6d. per copy.

Separate Conference Papers :

- "The Progress of the Electrical Grid," by Robert Blackmore, M.I.E.E. 3d.
- "The Production and Use of the New Smokeless Fuel 'Dryco' in Liverpool," by Ralph E. Gibson, M.Inst.C.E., M.Inst.GasE. 3d.
- "Atmospheric Pollution as Affecting Visibility and Visibility as Affecting Aviation," by Messrs. M. G. Bennett, M.Sc., and F. Entwistle, B.Sc., of the Meteorological Office. 3d.
- "The Influence of Air Pollution upon Vegetation," by W. W. Pettigrew, V.M.H. 6d.
- "The Complete Gasification of Coal," by T. R. Wollaston, M.I.Mech.E. 3d.
- "The Fuel of the Future," by Sir Francis Goodenough. 3d.
- "Powdered Fuel and the Smoke Problem," by Dr. J. T. Dunn, D.Sc., F.I.C. 3d.
- "How Electricity Can Help in Abating Smoke," by Julius Frith, M.Sc., M.I.E.E. 3d.
- "Power from Sources other than Coal," by Prof. Miles Walker, M.A., D.Sc. 3d.
- "Furnace and Tank Boiler Design," by W. H. Casmev. 3d.
- "The Smoke Inspector and the Cost of Production," by H. G. Clinch, M.R.San.I., M.I.H. 3d.

Published by other Organizations :

- "Clear Air for Leeds." pp. 52. (Leeds Tercentenary Committee). 3d.
- "Smoke Abatement and Fuel Economy in Steam Boiler Practice." (Manchester and District Regional Smoke Abatement Committee). pp. 11. 1d., post 2d.
- "The Open Fire." (Manchester Air Pollution Board). 1d., post 2d.
- "The Black Smoke Tax." Report of an extensive investigation into the cost of smoke in Manchester. (Manchester Air Pollution Board). 1d., post 2d.

Ready Shortly :

- "The English Law Relating to Air Pollution," by Randolph A. Glen. Also an entirely new pamphlet for general distribution on the domestic smoke problem and smokeless methods.

NATIONAL SMOKE ABATEMENT SOCIETY

President : H. A. DES VOEUX, M.D.

Chairman and Hon. Treasurer : ALDERMAN WILL MELLAND, M.A., J.P.

Hon. Advisory Secretary : Sir LAWRENCE CHUBB.

General Secretary and Editor : ARNOLD MARSH, M.Sc. Tech., M.Inst.F.

Vice Presidents :

H.R.H. THE PRINCESS LOUISE, DUCHESS OF ARGYLL.

THE RIGHT HON. THE EARL OF STAMFORD

THE RT. REV. THE LORD BISHOP OF LONDON, P.C.,
K.C.V.O., D.D.

THE RIGHT HON. LORD NEWTON, P.C.

THE VERY REV. THE DEAN OF CANTERBURY.

THE VERY REV. THE DEAN OF WELLS.

SIR THOMAS BARLOW, Bart., K.C.V.O., F.R.S.

SIR OLIVER LODGE, F.R.S., D.Sc.

SIR NAPIER SHAW, Sc.D., F.R.S.

Sir ERNEST SIMON.

PROFESSOR J. B. COHEN, Ph.D., D.Sc., LL.D., F.R.S.

PETER FYFE.

Alderman W. E. HINCKS, J.P.

DR. J. JOHNSTONE JERVIS, M.D., D.P.H.

Coun. W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.



FIFTH ANNUAL CONFERENCE

to be held at

SHEFFIELD

SEPTEMBER 22nd, 23rd, 24th

1933

PROGRAMME

PROGRAMME

FRIDAY, September 22nd—

8 p.m. RECEPTION by the Lord Mayor of Sheffield (Alderman Ernest Wilson) in the Town Hall. Invitations will be sent to those intimating their intention of being present at the Conference. (*See accompanying reply form*).

SATURDAY, September 23rd—

9-30 a.m. In the Memorial Hall, City Hall.

ANNUAL GENERAL MEETING

Chairman: The President.

AGENDA.

1. Presidential Address.
2. To approve the Minutes of the previous Meeting.
3. To receive the Annual Report.
4. To receive the Annual Statement of Accounts.
5. Election of President.
Vice-Presidents.
Hon. Treasurer.
Council.
Executive Committee.
6. The following Resolution will be proposed on behalf of the Scottish Branch of the Society:
"That the Ministry of Transport be respectfully requested to take the necessary steps to amend Regulation No. 18 of the Statutory Rules and Orders, 1931, made under the powers conferred upon him by the Road Traffic Act, 1930, by inserting after the word 'fuel' occurring in the said Regulation, the words '*shall only use smokeless or non-bituminous fuel and*'"
[Note: The Regulation, if amended in this way, would read:
"18. Every motor vehicle using solid fuel *shall use only smokeless or non-bituminous fuel and* shall be fitted with an efficient appliance for the purpose of preventing the emission of sparks or grit, and also with a tray or shield to prevent the ashes and cinders from falling on to the road."]
7. Any further business.

10-30 a.m. CONFERENCE. FIRST SESSION.

Chairman: Baillie W. Brownhill Smith, M.V.O., O.B.E., D.L. (Acting President, Scottish Branch).

Paper by Councillor W. Asbury, Chairman of the Sheffield, Rotherham, and District Smoke Abatement Committee, on:

"The Five Years Clause and other Matters arising from the Public Health (Smoke Abatement) Act, 1926."

Discussion.

2-30 p.m. Leave the Grand Hotel in motor buses for the Smithy Wood Gas and Coke Plant.

The Smithy Wood Plant of Messrs. Thorncliffe Coal Distillation Ltd., constitutes one of the largest Coke Oven and By-product installations in the country. It consists of a battery of 59 Becker type Coke Ovens of the latest design treating 1,200 tons of coal per 24 hours, together with complete By-product Recovery Plant in which Tar, Sulphate of Ammonia, Motor Spirit, and Coal Gas are produced. Carefully selected coking coal is brought by aerial ropeway from the collieries of the parent Company, Messrs. Newton, Chambers & Co. Ltd., and the resulting coke is carefully graded into sizes suitable for various purposes.

If time permits the return journey will be made *via* Wentworth Park and village.

8-0 p.m. At the Grand Hotel. Informal Meeting and Discussion.

SUNDAY, September 24th—

10-0 a.m. CONFERENCE. SECOND SESSION. In the Memorial Hall, City Hall.
Chairman: Dr. J. Rennie, M.D., Medical Officer of Health, Sheffield.

Paper by Mrs. Millicent Jast on:

“How the Citizen takes the Air—the personal significance of the Coal Smoke problem.”

Discussion.

11-30 a.m. Paper by Messrs. R. H. Clayton, M.Sc., M.Inst.Gas.E., and Charles Gandy, on:

“The Combating of Domestic Smoke in Industrial Areas.”

Discussion.

2-30 p.m. Leave the Grand Hotel in Motor Coaches for Derbyshire Tour.

Itinerary: Froggart Edge, Calver, Middleton Dale, Monsall Dale, Ashford, Bakewell.

Tea at the Rutland Arms, Bakewell.

Return *via* Baslow, and if time permits, through Chatsworth and Haddon.

Contributions to Discussions.—Delegates taking part in the discussions are requested to hand a copy of their remarks to the Secretary at the time, or to forward them to him as soon as possible afterwards, in order that they may be included in the Proceedings of the Conference.

Literature and Exhibits.—Copies of the Society's publications will be displayed and may be purchased during the Conference. A selection of exhibition material will also be displayed.

CONFERENCE ARRANGEMENTS.

- Hotel.** The Conference Headquarters will be the Grand Hotel, Sheffield. Members and delegates in reserving their rooms should mention that they are attending the Conference in order that they may obtain the special terms which have been arranged. These are:
Dinner, Friday evening to Breakfast, Monday morning, inclusive, £2/8/0
Room, breakfast, luncheon, and dinner, per day - - - - - 17/6
- Reception.** Those desiring to receive an invitation to the Lord Mayor's Reception on the Friday evening should indicate this on the reply form, which should be returned as soon as possible. Morning Dress.
- Visit to Smithy Wood.** It is hoped that all attending the Conference will participate in this visit, which has been arranged through the courtesy of Messrs. Thorncliffe Coal Distillation Ltd. A brochure describing the plant is being specially prepared for the occasion and will be distributed on the Saturday morning during the Conference. Kindly indicate, on the reply form, if you intend to be present.
- Motor Excursion on Sunday.** Provided a sufficient number wish to participate, a motor tour will be made on Sunday afternoon through Derbyshire, as described in the programme. The charge will be 4/- per head, inclusive of tea at Bakewell.
- Meeting Places.** The Reception will be held in the Town Hall; the Annual General Meeting and Conference Sessions in the Memorial Hall of the City Hall; and the informal meeting on Saturday evening in the Grand Hotel.
- Sheffield Official Guide.** Copies of the Official Guide to Sheffield with maps, etc., will be forwarded to those attending prior to the Conference.
- Conference Fee.** A Conference Fee of 10/6 per member or delegate will be charged. This will entitle those attending to receive advance copies of the papers, etc., and subsequently a full report of the Proceedings of the Conference.
- Papers and Tickets.** Copies of the papers, Annual Reports, the Sheffield Guide, invitation card for the Reception, and tickets for Sunday motor tour, will be forwarded prior to the Conference to all from whom the reply form is received in sufficient time.
- Date for Reply.** The Secretary will be obliged if those intending to be present will return the accompanying reply form as soon as possible, and in any case **not later than September 15th.**
- Further Information.** Any further information may be obtained upon request from the Secretary, National Smoke Abatement Society, 23 King Street, Manchester 2, up to September 21st, and afterwards at the Conference Office, Smoke Abatement Conference, Grand Hotel, Sheffield.

23 KING STREET
MANCHESTER

BLAckfriars 0896.

ARNOLD MARSH,
General Secretary.

500

November, 1934

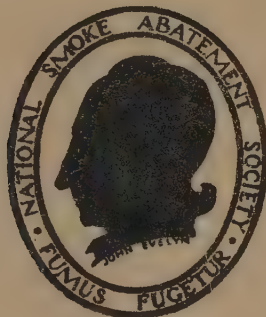
£ 38-0-0.

(price includes 300 proof copies)

C 31

National

Smoke Abatement Society



PROCEEDINGS

of the

Glasgow

Conference

1934

Price
One Shilling

36 KING STREET
MANCHESTER 2

List of Publications

(All prices include postage. Reduced Prices for quantities).

Smoke Abatement Handbook. A *vade-mecum* on all aspects of the smoke nuisance and its abatement. Contains authoritative articles, numerous statistics, and a variety of interesting facts. Indispensable to all who are concerned with the subject. 8vo. pp. 48. 6d., 5/- per dozen copies.

The Journal of the National Smoke Abatement Society. Published quarterly. Is not a record of proceedings but a magazine—the only one in the world—devoted to the problems of atmospheric pollution. Contains authoritative articles, notes on technical methods, news of activities of every kind, and in general keeps the reader up-to-date in every aspect of the subject. Per annum 2/6. Gratis to members.

Fumifugium; or the Smoake of London Dissipated, by John Evelyn. This rare and fascinating book, first published in 1661 by command of Charles II., has been republished by the Society with an introduction by Miss Rose Macaulay. It is illustrated with original wood engravings and a portrait of Evelyn. Paper covers 6d., cloth bound 1/6.

Home Fires Without Smoke. Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. Cloth-bound remainders 6d.

Smoke and Fumes Nuisances from Road Vehicles. Technical and scientific aspects by Dr. J. S. Owens, A.M.Inst.C.E., M.I.Mech.E.; and the legal position by R. P. Mahaffy, M.A. 8vo. pp. 16. 3d.

Smoke and Health. By Dr. J. S. Taylor, M.D., D.P.H., Assistant Medical Officer of Health, Manchester. 8vo. pp. 12. 2d.

Smoke Abatement in Salt Lake City, Utah. A full and illuminating report of the intensive and successful campaign in Salt Lake City. 8vo. pp. 43. 3d.

N.S.A.S. Annual Reports. Gratis, by post 1d.

Conference Reports and Proceedings:

Proceedings of the Newcastle Conference, 1932. Containing the Presidential address, papers by R. A. Mott, on "The Domestic Smoke Problem: the Possibilities of Coke Oven Fuel"; Alderman David Adams, on "The Psychological Effects of Smoke"; A. E. Crossley, on "The Human Element: A Factor in Smoke Abatement." With discussion. 8vo. pp. 63. 1/-.

Continued on back cover.

PROCEEDINGS
of the
 Sixth Annual Conference
of the
 NATIONAL SMOKE
 ABATEMENT SOCIETY
 HELD AT
 Glasgow
 September 28th and 29th
 1934



CONTENTS :

Presidential Address by H. A. Des Vœux	...	...	...	...	3
Resolution on Grit Emission	...	...	...	...	7
Professor Currie's Address	...	...	...	...	11
"The Measurement of Atmospheric Pollution"					
by Dr. J. S. Owens	...	...	...	...	14
Discussion on Dr. Owen's Paper	...	...	...	...	26
"The Effects of Smoke upon Visibility and Aviation"					
by Oliver Cochran	...	...	...	...	29
Discussion on Mr Cochran's Paper	...	...	...	...	36
"The Effect of a Smoke-Laden Atmosphere on Horticulture"					
by Wm. D. Besant	...	...	...	...	40
Discussion on Mr. Besant's Paper	...	...	...	...	43
"Nature is Beautiful" by Bailie W. Brownhill Smith	...	...			48
Discussion on Bailie Smith's Paper	...	...	...	...	53
Remarks by County Councillor H. Alston Hewat...	...	...			58
"Slum Clearance and the Smoke Problem"					
by Dr. J. Johnstone Jervis...	...	...	...	...	58
Discussion on Dr. Jervis's Paper	...	...	...	...	67
Text of Resolution on Housing...	...	...	...	...	70

Friday morning, September 28th. Annual General Meeting.

PRESIDENTIAL ADDRESS.

By

H. A. DES VOEUX, M.D.

Through the hospitality of the Lord Provost and Corporation we are assembled in this great city to preach the gospel of cleanliness, and it seems that it is almost an impertinence of us to come to a centre which has been in the forefront of the battle for so many years, where the authorities are fully in favour of what we have done and are doing, and when many of the protagonists—and without mentioning names I am sure you can call to mind at least two of them—are citizens of Glasgow.

But in spite of all that has been done during the 34 years of this century, are we and ought we to be satisfied with the result? We know that in most cities there has been a great improvement and our gauges prove it, but, and the but is a very big one, the residuum is still enormous, and a disgrace to our civilization. Thirty years of work and still a fall of 250 tons per square mile in this city as calculated from the average of nine recording stations of which the highest gives a figure of 285 tons per square mile and the lowest 160—a difference of 120 tons within your own boundary; and even this figure is 55 tons higher than Marple and 63 higher than Malvern. Let your aim be high!

We cannot—although memories be short—forget the continued outcry that rose against the fogs last winter in the towns and especially in London, which were, according to the reports received from those about middle age, “the worst ever experienced,” not perhaps from their density but from their frequency. In general they were described as being overhead, and as causing darkness and almost continuous gloom, seldom delaying traffic, but depressing to a degree not previously known from the darkness and foul smell. During all those months we who live in the brighter parts of England were able to enjoy a sunny and bright winter that brought joy to our hearts and made us realize that for a pleasant and agreeable winter it was unnecessary to leave our shores.

In the very description of those fogs we of the older age are able to derive some encouragement, for we can recognise that the atmospheric condition is definitely improved and that the warm air of the city is able to lift the smoke above the level of the ground and that although the air is still grimy it is not

so heavy with dirt but that the warmth produced from the heating of fires can partially dispose of it. Another point which can cheer us a little is that although London, and probably all the largest cities of the country, are superficially of much greater extent than they were, and that the inhabitants are better housed and better warmed, the heat is to a considerable extent produced by one of the many forms of smokeless fuel.

But can we be content with this slight but undoubted improvement? Certainly not—we have a long way to go yet. Our Society this summer arranged a very successful meeting, the subject being “Smokeless solid fuels.” It was a well-attended meeting and the papers were full of interest. They gave information on all those questions about such fuels with which we have been pilloried for many years. All of us have been twitted on the subject of smokeless heating of dwellings and when we have answered that we recommend gas, electricity, or central heating, we have been indignantly told “I am not going to give up my open coal fire unless I can have a similar one.” No doubt until a few years ago most of us were at a loss to answer this question, but a revolution has occurred in this regard, and the Society thought that it could not do better than allow all the producers of these fuels to meet and discuss and proclaim. This each and all of these gentlemen did to our complete satisfaction.

Unfortunately most of those present were the converted few; and I cannot think that the good news has reached the general public. The newspaper reports which I read were mostly scanty, short, curt, and unenthusiastic. The most pithy one was a short description of the Chairman, and was the only one of which I received more than one copy, but it had no reference to the subject under discussion. I should be greatly interested to learn from those who read the papers whether any of them have found that their clear statements of the value of their products have brought them any real advantage from the business point of view. I doubt it. If there had been, as there ought to have been, a deep stirring of conscience with regard to the pollution of the atmosphere some organs of the Press would have seized upon the subject, given it large headlines, and forcibly drawn attention to its importance.

Until we can obtain such publicity we are not going to carry the subject of “Clean Air” to an issue. Surely we have preached and preached until our brains are empty of new subjects—and how many disciples have we procured? Even in this enthusiastic city how many out of its million inhabitants care two straws whether the air is clean or dirty,

or would take any effort on their own accord or speak a word in our favour? Where is the fault? Is it ours or theirs? If ours will no one inform us what we can do more than we have done?

From this very city came the great truth that fogs are a prolific cause of that death-dealing malady, bronchitis and its consequent heart disease. The evidence produced here has been corroborated with convincing strength by Manchester, and in the reports of nearly every Medical Officer of Health. And bronchitis and heart disease produce 37% of the deaths in this country.

Further it is proved beyond cavil that one of the chief causes of rickets is darkness—absence of sunlight, and that this disease is the early stage of much of the crippling of children, which unless cured in a very early stage remains permanent. To those two may be added tuberculosis, both of lungs and bones, for although we do not claim that that is the only cause it is certain an ancillary one, and quite certainly it is almost impossible to cure it without the assistance of clean air and sunshine. Think of the expense of the Sanatoria and Homes for this disease alone—and further consider for one moment the futility of this type of treatment—the only available one at present. A patient is sent to a Home, remains a certain length of time until the disease is “arrested,” for one cannot speak of cure for at least three years. He returns to his own home, and returns therefore to the same surroundings where the disease started, and if you will take the trouble to read, as I have done, the after-history of these patients, you will perhaps agree with me that as a “cure” for tuberculosis the greater part of the money spent on Sanatoria is wasted. It would be far better spent on prevention, for tuberculosis is more easily prevented than cured.

Now in one short sentence I wish to refer tentatively to one other disease—cancer. Can we attribute this to a smoke-laden atmosphere? It is known that tar can produce this disease—this is a proved fact. The chemists have now isolated the element in tar which can do it, and I should not be surprised if before many years have passed further proof of the connection of tar and cancer will be forthcoming. Why has cancer of the lung from being an uncommon disease become a not infrequent one?

Again I say what will arouse the conscience of the man in the street, or the woman, or both? For unless we can do this the fight will continue for another thirty years. Can we find the Prophet who will do it? England has failed; cannot Scotland fill the gap? Are there no Knoxs or Burns to take

up the mantle and preach the gospel of cleanliness? We do not want to create alarm, but we do want those who live in our cities to recognise that they live under unhealthy conditions conducive to maladies which not only cause discomfort and annoyance and temporary disablement, but dire diseases of a nature persistent enough finally to undermine strength and vitality and lead to an untimely end. All the other evils of a uneconomical use of our most valuable raw product (more valuable than the gold of South Africa) are well known to those who wish to learn, but they do not yet seem to have penetrated to the brains of even the intelligent sections of the population. The terrible waste of the fuel itself—the throwing into the atmosphere daily and universally of precious by-products, tar, sulphur, and oil, all of which are of use in yearly increasing quantities, but which are thrown by a thoughtless population into the air to befoul and destroy our buildings, our art galleries, our clothes, books, and furniture; which necessitates frequent painting both inside and outside the house in order to make our residences look even reasonably clean, and adds enormously to the cost of living by the necessary renewals of curtains, sheets, carpets, towels, and other perishable household goods.

One other point—what about the general aspect of our big towns? Which of us in this room could pay a visit of pleasure to any of our manufacturing towns? Can you imagine yourself selecting any one of them for your summer holiday? Attractions they have in plenty—museums, theatres, concerts, good hotels, and all the etceteras that go to make life attractive—many glorious galleries and wonderful buildings; but they are spoiled by one great, unhideable, ever-present, but avoidable, sordid dowdiness. Make your cities light and cheerful and you will make life more bearable for those who dwell therein and more attractive to visitors.

There is one further point to which I should like to draw the attention of this Conference and which seems to me of the greatest importance. You all know that the Smoke Abatement Acts invite local authorities to make byelaws under the Acts, but there is no compulsion, and there are several large and important towns which have not yet done so, and as you drive through that part of the country you can recognize their delinquency from the filth in the atmosphere.

Finally, may I without insult say to the inhabitants of the second largest city of this great Empire:

“O wad some Pow’r the giftie gie us
To see our town as ithers see it
It wad from mony a blunder free us
and foolish notion.”

RESOLUTION ON GRIT EMISSION.

Mr. L. H. Dibblin (Willesden), in moving the resolution, said he would ask indulgence for a few minutes while he explained the reason for the resolutions that were down in his name.

The nuisance was from grit which was discharged from nearly all steam-raising plants using pulverized coal as fuel. For the benefit of those who did not know let him say that the coal was ground up—milled—into small grains and flowed into the combustion chamber where it ignited and the incombustible content of the coal—ash—was carried by the draught through the flues into the stack, whence a varying percentage of these fine particles was emitted to be deposited on surrounding property.

There were three main methods adopted to arrest grit.

- (1) Centrifugal arrestors—those arrested the larger grains only and failed to catch the finer particles.
- (2) Gas washing—this was reasonably effective where there was an abundance of water but where the supply was limited and had to be reused there was frequent trouble owing to excessive wear on the pumps.
- (3) Precipitation by electricity—this was an effective method, arrested very fine particles but was said to be expensive to instal and maintain and difficult of adaptation to existing plants.

The makers of these plants each claimed high percentage efficiency and although they as representatives of Local Authorities were interested in the amount of grit arrested by whatever means employed, their greater concern was with the amount of grit that escaped, polluting the atmosphere and a menace to health. One had only to inspect the dwellings and streets in the vicinity of the works to realize how great was the nuisance, the grit even entering through the cracks and crevices of closed doors and windows.

The Electricity Commission's Report on this subject was well worth perusal. It was a collation of scientific data on installations in this country and abroad and it set out what could be done by the various methods, with comparative costs of each, but it did not state nor indicate by which apparatus they could obtain 100% efficiency nor did it make any recommendations to that end. Indeed it rather inferred they had not much to complain about and that everything was well in that best of all worlds. He was neither a scientist nor an engineer and he did not presume to be able to give a solution to the difficulties but he did know the nuisance existed and

submitted that it should be abated and the best efforts of the Society should be directed towards that end.

The Law. All were familiar with the powers under the Public Health Act, 1875, and the Public Health (Smoke Abatement) Act, 1926, and particularly with that "best practicable means" defence in Section 1, subsection 3, and would realize that by those words, the onus was really placed upon the complainant to prove that the defendant had *not* taken the "best practicable means."

Again if the summing up of Lord Justice Scrutton in *Farnworth v. Manchester Corporation* was read, substituting the word "*grit*" for "*sulphur*" it would show the invidious position in which Local Authorities were placed: "If the defendants could prove that it was the inevitable result of a generating station that it should damage adjoining agricultural land by sulphur deposits, it was for them to prove it and they had not satisfied him (the Lord Justice) that they had taken all reasonable precautions to explore the causes of and remedies for that damage, or adopted all reasonable precautions to prevent it." He ventured to suggest that with this ruling before them, there was not a Local Authority that would enter into litigation against a Statutory undertaking.

Earlier in the year Mr. Dibblin was instructed by his Authority to get the Society to investigate this matter and after some correspondence with the officers and executive committee, he appreciated that the resources of the Society would not run to employing experts—experts cost money and they had not the necessary funds at their disposal. He had, therefore, to resort to this method of procedure.

It had become necessary that Local Authorities be given a lead from the Government, as to how this nuisance was to be combated and as this would require an amendment of the law, he moved that the Conference pass the following resolutions that had been circulated:—

"THAT this Conference of the National Smoke Abatement Society recommends that the Government set up a Committee to investigate and report upon measures to be employed to abate nuisances arising from the use of pulverized fuel, and that special consideration be given to the abatement of nuisance arising in connection with generating stations or other statutory undertakings."

THAT all Local Authorities be circulated asking them to pass a resolution on similar lines and that such resolution be sent to the Minister of Health and their respective Members of Parliament."

Mr. J. W. BEAUMONT (Halifax) formally seconded the resolution.

COUNCILLOR C. E. KEENE (Leicester) said that there was another side to the question that Mr. Dibblin had presented. They were spending the ratepayers' money, and must therefore think carefully before any definite move was made. More damage was done by sulphur than by grit.

ALDERMAN LUCAS (Birmingham) said grit was often caused by the burning of cheap coal, and one remedy was therefore to use a good quality coal that would produce but little grit.

COUNCILLOR G. W. CRAWFORD (Heriot-Watt College, Edinburgh) said that the matter of eliminating smoke and noxious gases from factory chimneys was one which was as interesting as important. Grit arrestors certainly prevented some of the worst smoke troubles, in a limited scope. There were chemical methods for treating the gases, but the only plant he had seen gave off clouds of steam. He had no doubt that this was perfectly innocuous, but it was not suitable for many situations. Further, it was very expensive. Electrical precipitation was less costly and, in his judgment, better from a scientific viewpoint.

In the latter days of the Great War he had charge of the erection and working of the first one in Europe. The Cottrell Precipitating plant was first brought out to throw down dust, but it would not naturally precipitate any solid matter in suspension. The plant he was concerned with was in the Government's largest T.N.T. works in the country, and if he remembered aright it collected 30 tons of liquid a day, 50% being sulphuric acid. It might be argued that sulphur dioxide, being gaseous, would not be thrown down, but it was highly soluble in water and globules of it would gather on the solid matter in suspension.

The objection that this would not be 100% perfect was a valid one, but what process could be? If it was 90% efficient surely that was a wonderful improvement till a further development took place. As a matter of fact he believed that it would cure 99% of the smoke and 90% of the gaseous contamination. Further, very inferior coal could be employed as its defect of smokiness would be of benefit in eliminating gases. In that direction, Councillor Crawford concluded, lay the real solution, and he could not understand the reluctance of the public authorities to investigate it.

Mr. R. H. CLAYTON said that considering the large sums being expended in England and abroad together with the research work being done in order to overcome the emission of both grit and sulphur fumes, the resolution was unnecessary. It made it appear that the Society did not know anything about the subject.

COUNCILLOR ALEX MUNRO (Glasgow) said that the resolution should be adopted. The Society was out for all kinds of air purification and must do all it could to help people who are troubled with the grit nuisance, even though it might not concern many of them.

Dr. B. WYLAM (Department of Health for Scotland) said he did not think that this Resolution would serve any useful purpose as the matter had already been investigated and reported upon by the Committee appointed by the Electricity Commissioners. In the Report published in 1932 the Committee set out their recommendations for grit elimination after considering the matter carefully and investigating the various methods available. Electrical precipitation had now reached a very high measure of efficiency and such a plant installed to treat the flue gases from the use of pulverized fuel would eliminate a very high percentage of the grit.

Had the resolution been worded so as to call upon local and other authorities to use the methods already known, he would have been in absolute agreement, but it seemed to him that the work of investigation had already been thoroughly carried out and no good result could accrue by requesting the Government to set up a Committee to investigate the matter for a second time.

Mr. Dibblin objected to the phrase so often used—"best practicable means." He, as a Civil Servant, maintained that those words used in Acts of Parliament and other measures were of great use to those charged with the administration of the law. No specific methods were detailed and the public were called upon to use the best available methods at the moment. Thus the progress of scientific research could be used in legal administration.

He maintained that the problem of grit elimination had been solved and that what was required was the application of the methods already available. He wished as much could be said for the elimination of sulphur gases from large boiler installations.

The resolution was adopted.

Friday, September 28th, Conference, 1st Session.

Chairman:

Professor J. R. CURRIE, M.A. (Oxon), M.D.(Glas.), M.A.,
F.R.C.P.(Edin.), D.P.H.(Birm.), University of Glasgow.

Professor CURRIE said:—

I am greatly honoured by the invitation to take the Chair at this First Session of the Sixth Annual Conference of the National Smoke Abatement Society. I am always pleased to testify to my firm belief in the principles and practice of smoke abatement. Like every teacher of Public Health in the medical schools of this country I am a constant advocate of these principles, which I endeavour to instil into the minds of my students, with the result that every year we pass out from the University of Glasgow a goodly company of young doctors who know the mischief that smoke does and what should be done to prevent it.

It is easy perhaps to teach on these lines in a city like Glasgow, where the mental atmosphere is definitely favourable to smoke control, and where much has been achieved in the good cause. It would be unbecoming in me, as a citizen, to praise Glasgow beyond measure in this respect, but I may perhaps, borrowing a phrase from the President's address this morning, claim that the city now stands "in the forefront of the battle" for the purity of the air and, pursuing the military image, add the further information that in Glasgow the strongly entrenched positions of the great industrial smoke producers have been carried by frontal attack. Our gauges show that factory smoke has been reduced by some 20 per cent of the total output. There still remains the more difficult task of carrying on a guerilla warfare upon the individual bituminous coal fires in the people's houses. In this field too, some advance has been made. Let me indicate where our outposts lie. There are now on loan from the City Gas Department 240,000 gas cookers and 36,000 gas fires. Recently erected private houses contain 50,000 gas cookers and 60,000 gas fires. The Electricity Department is responsible for 5,000 electric cookers and 48,000 electric fires. And the Gas Department has issued in a year 240,000 tons of gas coke, mainly for industrial purposes.

All this is a formidable salient driven into the hostile territory, but the scheme will not be complete without another line of progress, the general use of solid smokeless fuel for burning in open grates. This question is one of high importance, for speaking as a medical man I have no hesita-

tion in saying that at the present time, on the grounds alike of comfort and health, smokeless fuel bears the palm for use in the living rooms of houses. I do not in any way seek to displace either gas or electricity from their proper spheres, but I maintain that in any effective general scheme for smoke abatement smokeless fuel also must be accorded an honoured place.

On the score of comfort the combustion of the fixed carbon in the solid fuel produces the red and short infra-red rays which possess a power of penetration. They are not stopped by the skin but pass through it and warm the blood beneath, so that we feel warmed through and through. The effect comes near to that of the sun bath, which is so pleasurable.

On the score of health the flue, which is inseparable in the civilized house from the open grate, exercises a powerful exhaust, passing 20,000 cubic feet of air per hour out by the chimney. This withdrawal induces a continuous change of air through the whole room. The movement is gentle, unperceived and free from draughts, and the air in the room, except for its genial warmth, scarcely differs from the fresh air of the open, which is the best for us all.

Another advantage may be noted. Aggregated open domestic fires have together a strong uplifting action on the overlying atmosphere, so that the combustion vapours, from both domestic and industrial fires, are dissipated high and wide and rendered innocuous by dilution. That this action is of moment is well shown by what happened on the Meuse, in a place where domestic fires are few, between Liège and Huy. Here in December, 1930, during a fog accompanied by great cold, 63 persons died in three days of a suffocative bronchitis. The reason was that the fumes from the local factories rose a little way, then cooled and quickly sank again with deadly effect, the uplift from the fires of the scattered houses being too weak to disperse them. In Liège, close by, where domestic fires were numerous, the inhabitants did not suffer, but there was a high fog.

By all means, therefore, let us utilize gas and electricity to the full, together with coke-fired boilers for central heating, but let us at the same time bear in mind that for health and comfort within the home and, as the Meuse fog showed, communal safety also smokeless fuel burned in open grates is the best method of heating. In Glasgow for a number of years the Corporation has been providing such fuels, and some of our acutest minds have been exercised upon their production. It seems to me entirely fitting that a great Local Authority should engage in the enterprize of making such provision. Health interests are closely concerned, and

the undertaking to be successful must be pursued on the large scale. Smokeless fuel should not be regarded or handled merely as a by-product of the gas plants of the city. It should itself be made the primary object in view, and the carbonization products dealt with as secondary items. If the question is thus envisaged it will be possible not only to turn out a smokeless fuel which will compete on favourable terms with raw coal, but also to produce it in adequate amount and at attractive prices. Once the material has made its way into general use, and once its good effects on the atmosphere have become apparent, it will have won for itself a place in the houses of the people from which bituminous coal will never cast it out.

But whatever policy we may adopt in our efforts at smoke abatement our action in practice must be guided by sure knowledge. Otherwise only disillusionment can be the result. For such knowledge we look to science, and the more complete our scientific acquaintance with the phenomena of air pollution, the more precise shall we be able to make our methods of controlling it. Science is essentially quantitative. It is a question of measurement, up to the limit of accuracy of the instrument used and the requirements of the problem investigated. There can be no better example of the utility of science so applied than in the activities of the Committee for the Investigation of Atmospheric Pollution. The superintendent of the Committee's investigations, Dr. J. S. Owens, whose distinguished work is well known to us, is here this morning and will read us a paper on the Measurement of Atmospheric Pollution, followed by the demonstration of a new instrument which he has devised for measuring smoke emission.

Our other speaker, Mr. Oliver Cochran of the Scottish Flying Club, will read us a paper on the Effects of Smoke on Visibility and Aviation. The smoke campaign has been in progress now over a somewhat extended period, and it has at times appeared as if we are coming near to a stage of equilibrium where victory is inclined to neither side, where

"The enemy faints not nor faileth
And as things have been they remain."

Even in the Presidential address one seems to detect the note of sadness, when the wearied Titan "doubts whether we are going to carry the subject to an issue." At such a time the appearance at our side of Aviation as a new ally is a notable encouragement. The proposal or the clearing of the airways may make a strong public appeal. The aviator himself is a spectacular figure, clad with wings and demanding high standards of what he calls visibility. It would accord well

with the general fitness of things if our final help in the smoke abatement campaign should come to us thus out of the air where all the trouble began.

I welcome in your behalf Dr. Owens and Mr. Cochran. I am sure we shall listen with the greatest interest and profit to what they have to say.

Professor Currie then called upon Dr. J. S. Owens to present his paper.

THE MEASUREMENT OF ATMOSPHERIC POLLUTION.

By Dr. J. S. OWENS, M.D., A.M.I.C.E.

In March, 1912, an International Smoke Abatement Exhibition was held in London, and at this Exhibition, there was a Conference on the subject. At this Conference, the following resolution was moved by me and seconded by Mr. Kershaw:—

“There in view of this Conference it is desirable that immediate steps should be taken to decide upon and secure the general adoption of a standard method for the measurement of atmospheric pollution by smoke and other products of combustion and heat, in order that the data now being collected may possess a comparative value, and that a Committee be appointed to draw up details of a standard soot and dust-measuring apparatus and methods of its use.

“That the Committee do consist of Dr. Des Voeux, Professor J. B. Cohen, B.Sc., Ph.D., F.R.S. (Leeds University), Bailie Smith (Glasgow Corporation), Dr. Hawksley (Liverpool), Dr. John S. Owens, M.D., A.M.I.C.E. (Coal Smoke Abatement Society, Dr. W. N. Shaw, M.A., D.Sc., LL.D., F.R.S. (Director, Meteorological Office), Dr. Vasey (“The Lancet”), and Mr. Kershaw (Hamburg Smoke Abatement Society) with power to add to its number.

“That the conclusions and recommendations of such Committee be reported to the delegates forming this Conference and to all municipal authorities in the United Kingdom.”

This was the birth of the Investigation into Atmospheric Pollution, which has grown steadily ever since and, after several vicissitudes, appears now to be firmly established under Government auspices as a section of the work of the Department of Scientific and Industrial Research.

It may be asked, What is the good of measuring the degree of pollution of the air? and this is a question the

answer to which is very important. Broadly speaking, if we wish to examine any subject closely, it becomes necessary to make some measurements and, in this particular case, it is evident that no clear idea can be obtained either as to the relative pollution of the air of different cities, or as to whether the air in a particular city is getting cleaner or the reverse, unless we are able to measure the pollution in some way.

The Committee, which originated, as above described, set itself, first of all, to find methods of measurement and, without describing the different experiments made and the progress towards the present position, I may say it was early recognized that in the measurement of atmospheric pollution, there were at least two quite distinct aspects of the problem to deal with. The first of these was concerned with the amount of impurity deposited out of the air at a particular place, and the second, with the amount which was actually suspended in the air at any particular place and time.

It will be seen that these two aspects are to some extent complementary, i.e. the suspended impurity represents the part which has failed to deposit. The rate at which the suspended matter deposits out of the air depends upon the size, shape and density of the particles; the smaller the particle, the slower will it settle out of the air. It is indeed possible that, when the size of the particles falls below some particular limit, they will not settle at all, even in still air, being held in permanent suspension by virtue of the molecular bombardment being greater on the under side than on the upper side, owing to the air being elastic and being compressed by its own weight. At any rate, the very fine particles of suspended matter, if they do ever tend to settle out, do so so very slowly that they can be and are carried over immense distances in the wind, the coarser particles settling to the ground nearer to their source.

In addition to the pollution of the air by particulate matter, there are also often present gaseous impurities and these call for a totally different technique in measurement. The gaseous impurities with which we are primarily concerned are those derived from the combustion of raw coal and the most important of these is sulphur in the form of sulphur dioxide.

Passing on now to a brief description of the methods at present in use by the Advisory Committee on Atmospheric pollution, I propose to take first the measurement of deposit.

The Standard Deposit Gauge.

This consists of an open-topped glass bowl, supported in a suitable stand. The bowl is about 30 cms. in diameter and terminates in a funnel-shaped bottom with a nozzle for con-

nection to a bottle placed on the stand underneath. The gauge vessel itself is made of glass and collects the rainwater and the impurities deposited from the air. These latter are washed into the bottle below and the bottle is changed once a month, the contents being analyzed into Tar, Carbonaceous Matter other than Tar, Insoluble Ash, Loss on Ignition, Soluble Ash, and, included in the Soluble Matter, Sulphates, Chlorine and Ammonia. Before changing the bottle, the gauge vessel is washed down with some of the water which has been collected in the bottle, so as to remove any impurities adhering to the sides. In the event of there being no rain during the month, the gauge is washed down with some distilled water.

The results are returned to my office from the forty co-operating authorities using this method of observation and which in all maintain 96 deposit gauges in this country. It was thought at first advisable to publish the amount of deposit in metric units, as it was hoped that the investigation would become international. The unit chosen was one metric ton per square kilometre, subsequently altered to one metric ton per hundred square kilometres or one gramme per square dekametre. The area of the mouth of the gauge vessel was ascertained for each gauge and this enabled us to calculate a factor which, when multiplied into the weight of the deposit in grammes, converted that figure into metric tons per hundred square kilometres. A similar factor converted the grammes of deposit into English tons per square mile. Thus, we have a uniform method of stating the results which permits direct comparison.

To show the value of these results and the sort of information they give us, I give below a curve (Fig. 1) which has been prepared from the results of the gauges in Glasgow, of which there are nine. This curve shows the average of these nine gauges over a period of years and you will see at once that soon after the investigation commenced, there was a rapid and marked improvement, but that this improvement has not been continued up to the present year. In the Figure, I have shown the total deposit for each year in English tons per square mile in one curve and in another the deposit of sulphates. This is because sulphates are primarily a product of combustion, being derived from the sulphur in the coal, and so they are a closer index of the improvement or otherwise than the total deposit, which includes dust blown up by the wind.

Taking the whole of the stations which we have had in operation during the years ending 31st March, 1933 and 1934, and reducing the deposit at all these stations to a single

average figure, we find that in 1933, this figure was, for Total Solids, 250 English tons per square mile for the year, and in 1934, 240.

To permit comparison with past years and to show whether there is any improvement going on or not, a figure has been calculated for most stations showing what we call the "General Average" deposit, i.e. the average for a certain five years, so that a place which has an annual deposit less than this average is improving, while if it is greater, it is



deteriorating. To give some idea of the amount of impurity deposited, I give below a list of some of the stations with the deposits recorded during last year and the "General Average" figure for the same place in a parallel column. In cities, which have a number of gauges, I have included only one of these, that nearest the centre of the city.

ANNUAL DEPOSIT OF TOTAL SOLIDS.

(English Tons per Square Mile).

Station	Average	1933-34
LONDON, King Charles Street	281	227
BIRMINGHAM, West Heath	134	185
BOURNVILLE, Works	138	126
BURNLEY, Town Hall	563	436
CARDIFF	181	138
CASTLEFORD	360	302
EDINBURGH, Princess Street	268	332
GARSTON	151	110
GLASGOW, Botanic Gardens	309	251
GLOUCESTER	180	132
HUDDERSFIELD, Cooper Bridge	352	112
KINGSTON-ON-HULL, Central ...	353	308
LEEDS, Park Square	355	343
LEICESTER, Town Hall	347	298
LIVERPOOL, Netherfield Road ...	575	535
LOUGHBOROUGH	296	242
MARPLE	169	94
NEWCASTLE, Westgate Road	388	267
ROCHDALE, Town Hall	280	229
ROTHAMSTED	116	85
ROTHERHAM, Oakwood Hall San.	147	160
ST. HELENS	462	316
SALFORD, Peel Park	388	236
SHEFFIELD, Surrey Street	398	372
SOUTHPORT, Hesketh Park	131	89
STOKE-ON-TRENT, Longton	298	282
WAKEFIELD, W.R. Rivers Board	283	241

The deposit gauge method of measuring is not to be regarded as absolutely accurate, but rather as giving a reasonably true picture of the state of affairs. The measurement is necessarily made at one spot and this may not be representative. Again, it is made over a comparatively small area, that of the gauge vessel, and this also may not be strictly representative. On the whole, however, I think it may be taken that these measurements give a fairly true picture of the degree of pollution at any place, as measured by the deposit from the air at that place.

Measurement of Suspended Impurity.

Turning now to the measurement of suspended impurity in the air: As the primary object of the investigation was to examine the pollution of the air by coal smoke and the soot from coal smoke is reasonably black, a method was evolved which consisted of filtering a known volume of the air through a piece of white filter paper and estimating the amount of pollution from the blackness of the spot left on the paper.

The first form which the instrument took was what we called a "spot filter," i.e. a filtering head, which received the filter paper, and a couple of Winchester quart bottles which

enabled two litres of air to be drawn through the paper. The whole of the air was forced to pass through a disc of paper $\frac{1}{8}$ " in diameter and the standard volume for filtering was fixed at two litres.

This spot filter method was very useful, but required an observer to take a record by manipulating the bottles, and it was thought that an automatic apparatus which would perform the operation without an attendant would be more generally useful. Such an apparatus was evolved and took the form of what is now known as the automatic filter. I will not describe it in detail the mechanism of this as it is not of general interest. Suffice it to say that the instrument filters two litres of air through a disc $\frac{1}{8}$ " in diameter and places the records so obtained upon the edge of a circular disc of filter paper, opposite the time at which the record was taken. The large filter disc has printed round its edge hours from 1 to 24. This automatic filter operates by means of water aspiration and requires a water supply, and a drain to carry off the used water. It takes about 2 to 4 records per hour and permits comparison to be made of the sooty impurity in the air at different hours of the day and night.

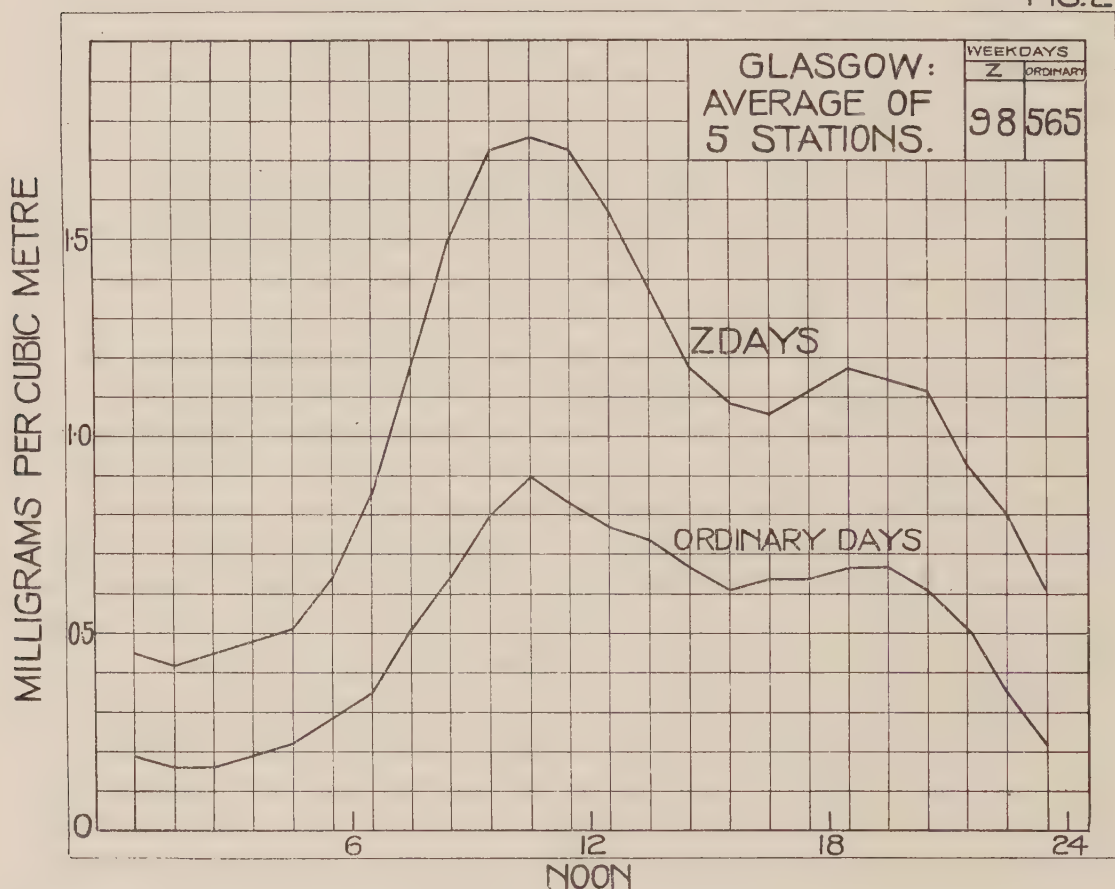
To convert the figures into quantitative values, a scale of shades of blackness was prepared with shades numbered 1, 2, 3, 4, 6, 8, 10, 12, 15 and 20. The degree of blackness on shade 1 is arbitrary, but having been fixed, all the other shades are multiples of this, i.e. shade 6 has six times as much black on it as shade 1. The scale are mounted in a frame behind glass in the form of a small strip with a $\frac{1}{8}$ " hole through the centre of each shade and under this hole, the record from the filter can be placed and matched with the shade.

It will be seen now that if we could ascertain the value of the arbitrary shade 1, all the other values would be known. This was ascertained in London by a somewhat elaborate method some years ago and there it was found that the value of shade 1 represented 0.32 milligrams of soot per cubic metre. It does not follow that the same shade in other cities would represent exactly the same amount, but as, in general, the causes of pollution in cities are much the same, i.e. from coal smoke, it is probable that there would not be very great differences in the values of the unit of shade. Armed with the instrument and the scale of shades, it was now possible to give numbers to the impurity recorded in the air at each hour of the day or night and this has been done for some years in several cities, notably in Glasgow, with very interesting results. I give below a curve (Fig. 2), showing the average of five automatic filters in Glasgow for the winter 1933-34, and you will see from this that there is a very definite dis-

tribution over the 24 hours. The air is clean in the early morning, then gets rapidly dirty as fires are lighted, attaining a maximum of impurity about ten o'clock and then gradually clearing as the day goes on. In the Annual Reports, published by the Department, an arbitrary division of days, based upon the records of this instrument, has been made, into hazy days, called "Z" days, i.e. days on which the recorded impurity reached or exceeded shade 4 on the scale, and "Ordinary" days when it did not reach shade 4.

When smoke fog comes on in a city, the shades of these records darken very much, but very rarely is shade 20 reached. Smoke fogs, as you are probably aware, are simply due to the

FIG. 2.



banking up of the smoke of a city which is ordinarily swept away by the wind. Hence the density of the records obtained during such fogs.

As the instrument above described requires a water supply and a drain, it is not possible to use it where these are absent. Hence, a modification has been evolved in which exactly the same operations are performed by means of the energy of a falling weight connected through gearing to a suitable aspirating bellows. A photograph of this instrument is given (Fig. 3), and it has the advantage that it can be used anywhere and is not limited to places where a water supply is

available, or even electric power. An additional refinement has been added in the form of a wind vane, mounted above the instrument but not shown in the photograph, which stamps the wind direction upon the filter disc at the time the record is taken. This is of some importance when it is desired to know the direction from which the impurity recorded is coming.

The records obtained by such an instrument are clearly limited to those for impurity by black smoke and, while sub-

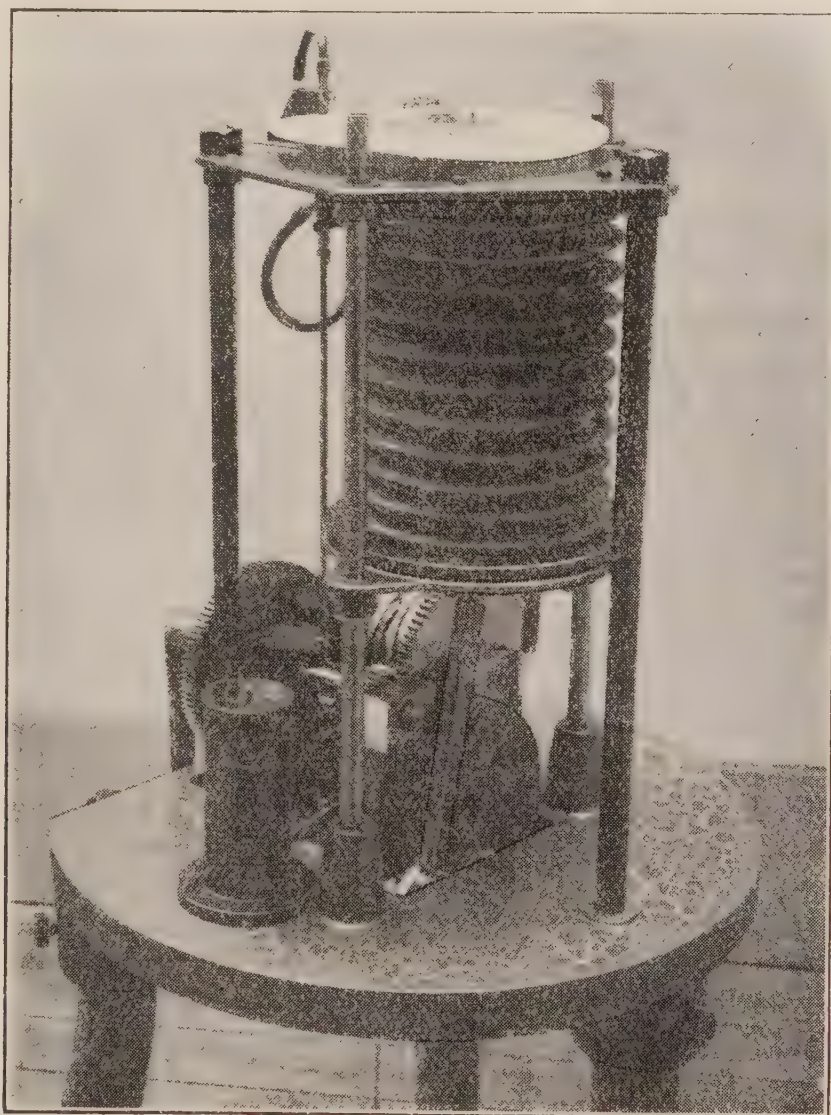


FIG. 3.

ject to this limitation, it has been found that remarkably reliable records are given. For example, a curve showing the average impurity so recorded in a city during a particular year is sometimes almost exactly reproduced when a curve of the following year is plotted,

In practically all cities there is a general distribution of the impurity of a similar kind, i.e. the air after about midnight rapidly clears and does not begin to show much impurity until the early morning about five or six o'clock. There is then a rapid increase due to the lighting of fires, until a maximum is made in the forenoon about nine or ten o'clock, a maximum which is found to be about an hour later on Sundays than on weekdays. After this, the impurity falls rapidly until late in the forenoon, making a minimum about 3 or 4 p.m. and then it rises again to a second, usually lower, maximum about 7 to 8 p.m. After this, there is a gradual clearing up to midnight.

The records of such an instrument can be preserved and referred to later for comparison with past years and they enable us to compare the density of smoke fogs as well as the general level of impurity, and to say whether this is improving or otherwise.

Dust Counting.

A method for examining the nature of the suspended impurity microscopically was evolved in the form of the Jet Dust Counter and this instrument enables a sample of 50 c.c.'s of the air to be taken, the dust content precipitated upon a cover glass and examined under a high power microscope. The standard dust counter gives a linear record 1 cm. long and in the form of a thin line. Thus, it is a simple matter to count, by the aid of a square-ruled micrometer eye-piece, a strip across the record at a few points, and, from this, the total number of dust particles contained on the record can be calculated and the number per cubic centimetre in the air. The dust records taken by this instrument show that the air is never entirely free from dust; even in the open country, there are two or three hundred particles per c.c., while in cities, such as Glasgow or London, the number would range from about 4,000 or 5,000 to perhaps 100,000 during smoke fogs.

Examination of dust records taken in this way shows that the dust in cities, when it is derived from combustion processes practically always contains a certain proportion of spherical particles. These are perfectly spherical but minute balls which are due to the fusing of ash in fires and furnaces and its solidification while suspended in the air. They appear in all colours, white, black, yellow and red, and some perfectly clear transparent balls. The majority of the dust particles are however, irregularly shaped and consist of soot and wind blown dust. During a smoke fog, a very dark record can often be obtained, and when this is heated in close proximity to a cover glass, kept cool by a drop of water, the tar in the record

volatilises and condenses on the cooled cover glass, forming another linear trace.

Sometimes records may be obtained showing crystals of various kinds and the formation of these crystals can be promoted by the method of taking the record, while a microscopical examination will often indicate the nature of the salt which has crystallized. A method of identifying these salts by means of the vapour pressure of their saturated solutions was evolved and described by me in "Condensation of Water from the Air upon Hygroscopic Crystals."* The fact that there are not a large number of salts which can find their way into the air makes this method reasonably applicable. It would take too long, however, to describe it here. suffice it to say that if the crystals are exposed successively to the vapour from a saturated solution of the probable salts in ascending order of their vapour pressures, while they are kept under observation on the stage of the microscope, if the vapour pressure of the crystals on the record is greater than that to which they are exposed, nothing will happen, but when exposed to a solution which has a higher vapour pressure than the crystal, the latter commences to deliquesce and so can be identified.

Sulphur Measurement.

The examination of the sulphur pollution in the air has become of increasing importance since it is known that this is the main cause of injury to buildings, while it is also a strong irritant when present in any quantity, as it sometimes is during smoke fogs and is thus very injurious to people suffering from respiratory diseases.

Two methods have been evolved for the measurement of sulphur. Under normal conditions the sulphur in air appears to be present almost entirely as sulphur dioxide, the amount of sulphuric acid being usually negligible. The sulphur dioxide can be determined by absorption and fixation as sulphuric acid in an aqueous solution of hydrogen peroxide, the most convenient form of the peroxide being the solid compound of perhydrol and urea known as hyperol (Berk). Air can be bubbled at a rapid rate through this solution with complete absorption of sulphur dioxide. A process based on the same principle, but using hydrogen peroxide itself as oxidizing agent, was described and used in 1891 by the late Dr. G. H. Bailey. The details of the process now described were worked out by the Government Chemist (who has used it for some time) for the Atmospheric Pollution Research Committee of the Department.

* Proc. Roy. Soc., A, Vol. 110, 1926,

Air is collected from the desired source by means of a glass or rubber tube from which a small glass funnel depends, serving to prevent rain or gross dust from getting into the absorbing vessel. It then passes through the absorbent solution, which is contained in a reaction tube of stout glass about $1\frac{1}{2}$ " diameter and 10" long, fitted with a rubber two-bored bung, carrying a tube reaching to the bottom and with a shorter tube in the second hole reaching only just through the bung. After leaving this vessel, the air passes through a conical flask of about 250 c.c. capacity, serving as a trap, and thence to a gas meter capable of registering 100 cubic feet. This may be a small dry meter such as is used for small domestic services, and must be of at least the degree of accuracy required by statute for this purpose—that is, it should bear the seal of a competent testing authority.

The air is drawn through the apparatus by means of a suitable pump, which may be an electrically driven blower, used as an exhaust, or an ordinary laboratory water pump. This method gives the concentration of sulphur dioxide in the air on any particular day.

A second method was evolved which consists in the exposure of a porcelain cylinder coated with a paste made of lead peroxide. The cylinder is left out for a month, after which it is removed, the lead peroxide having been partly converted into sulphate which is estimated and a figure obtained for the amount of sulphate per 100 square cms., which is about the area of the cylinder surface. It will be seen that the two methods are totally different and the latter does not give the concentration, but what may be called the "active" sulphur, since the attack on the lead peroxide cylinder depends, not only on the concentration, but also upon the exposure and the wind and other factors. It is a better measure of the amount of injury which may be expected to building stone from sulphur in the air than is the volumetric method which gives the concentration. The results obtained by the former method show that in an industrial area, the concentration of sulphur dioxide is usually about 0.2 p.p.m. by volume over a period of 24 hours, although in special conditions, it rises very much above this. The concentration over any hour of the 24 may rise to over 10 parts per million, but this would be very bad. When measuring over a period of 24 hours, the figure obtained is an average and it is fairly certain that in ordinary cases the distribution of the sulphur will be not very different from that of the soot as indicated by the automatic filter. Hence, the night time would give very little in ordinary circumstances, while early in the forenoon a maximum would be reached.

The lead peroxide cylinders usually give, for city air, about 0.2 grms. SO_3 per 100 square cms. per month in the winter and about one-third of that amount in the summer.

A great many criticisms have been levelled at the investigation of atmospheric pollution and very often they have come from places where an excessively high degree of pollution has been found. It is then only human to throw the blame upon the methods of measurement and this is what sometimes happens. It is difficult to obtain sites for measurement which are not open to any criticism. In the case of the deposit gauge, it must not be in a position where it will be interfered with by boys or liable to being broken by stones, as it forms an attractive target. Thus, the sites for the gauges are the best which can be found in the circumstances, but are often subject to some drawbacks. In cities, parks are usually the best sites. Failing this, the flat roof of a building is sometimes very useful. It is difficult to get a site which is not sheltered in some way by surrounding buildings, or is not subject to artificial pollution by leaves from trees and so on. All these criticisms can be levelled at the methods, but when all is said and done, there is no doubt that the results obtained give a reasonably true picture of the degree of pollution of the air. It is not necessary to obtain extreme accuracy in things like this, in fact, it is a pure waste of effort, since the ultimate object of the whole investigation is concerned with the reduction of impurity and unless there are errors of such a magnitude as to make the methods unreliable as a guide, small errors do not really matter much. All the methods described have been very fully tested and examined by the Research Committee and may therefore be accepted with reasonable confidence as giving the sort of information which we require.

Perhaps one of the main uses of this investigation is to bring home to the public the degree of pollution of the air and their own responsibility in the matter. That this has been done is fairly evident, since no power station would now be erected in a city unless adequate provision was assured for preventing the emission of serious impurities. The investigation has therefore fulfilled its object up to a point, but a great deal more remains to be done, as anyone who studies the Annual Reports will see. While a certain amount of improvement has taken place, the rate is very slow and it is necessary that efforts to improve matters should not be relaxed.

Dr. Owens, at the conclusion of his paper, gave a demonstration of the working and use of his new smoke meter, a brief description of which is as follows:—

On a shaft at the top of the instrument four black discs are mounted, one behind the other. Each disc has four projecting vanes. In something the manner of a fan, these vanes may be arranged to be all behind the other, or, alternatively, in echelon. In the first case, if the discs are spun, only about one-fifth of the light is obstructed when any object is viewed through them, and in the latter about four-fifths. Intermediate positions provide different readings.

In use the instrument is held by the handle in the right hand with the discs facing away from the observer, and a large hollow adjusting nut, at the other end of the horizontal shaft, towards him. The hand is kept clear near the top of the handle in such a position that the thumb will comfortably engage the knobs of a star wheel that projects towards him below the shaft. The disc is now revolved by pressing the knobs of the star wheel with the thumb. The left hand holds the adjusting nut and thus serves to steady the instrument, while, at the same time, the nut is turned to alter the percentage of obstruction caused by the revolving arms.

When observing the smoke from a chimney, the instrument is held in such a position that the light which falls upon the smoke is the same as that which falls upon the revolving disc. Then, revolving the disc sufficiently rapidly to eliminate flicker, the screw can be adjusted until the gray shade obtained by looking through the revolving discs at the background beside the smoke just at the top of the chimney just matches that of the smoke. When a match has been obtained the disc is stopped and the percentage of black, *i.e.*, the percentage of obstruction of light, is read on a scale on the front of the revolving disc.

DISCUSSION.

Dr. H. A. DES VOEUX said that at the formation of the Committee on Atmospheric Pollution he had said "We are not going to get very far in the smoke abatement question unless we measure the amount of dirt in the atmosphere." Dr. Owens was then appointed by the committee to investigate the measurement of pollution, and he has now for many years been the Superintendent of the D.S.I.R. investigation. All the instruments and means of measuring pollution, with one exception, have been invented by Dr. Owens, and he was very glad to have the opportunity of proposing a vote of thanks to Dr. Owens for his valuable paper and the demonstration he had given the conference that morning.

COUNCILLOR W. ASBURY (Sheffield, Rotherham and District Smoke Abatement Committee) said he wished to second and support the vote of thanks proposed by the President, and had the greatest pleasure in doing so.

Mr. J. W. BEAUMONT (Halifax) said that whilst one might agree with the general statement made by Dr. Owens that it was not necessary to obtain extreme accuracy in taking measurements

of atmospheric pollution, it was nevertheless a fact that for the purposes of comparison—one of the objects for which these records obtained—it was desirable that reasonable accuracy be secured.

It was therefore to be regretted that many local authorities would appear to be more concerned with showing their areas in a favourable light than in actually ascertaining the extent of atmospheric pollution in their midst. This was evidenced by the fact that the sites selected for the standard deposit gauges were in some cases far removed from the industrial area of the town, and therefore the records obtained could not be regarded as representing the amount of atmospheric pollution in the town.

Halifax, on the other hand, were anxious to know the worst, so to speak, respecting atmospheric pollution in its area, hence all the five deposit gauges were situate within an area of $1\frac{1}{2}$ miles from the centre of the town. The average of the records obtained from these gauges could be regarded as fairly representative of the amount of air pollution taking place in the town taken as a whole.

Geographical features also had an important bearing upon the amount of atmospheric deposit in any given area. For instance, in a flat district the winds had a scavenging action—as referred to by Dr. Massie, Medical Officer of Health for Coventry—and carried much of the smoke and dirt from factory and house chimneys outside the area in which they were situate, whilst in a district such as Halifax—practically surrounded by high hills—tended to bring down the atmospheric deposit near to its place of origin.

COUNCILLOR G. W. CRAWFORD (Heriot-Watt College, Edinburgh) spoke of the positions of gauges in making comparisons of other towns. Some gauges were much more favourably situated than those in other towns. It would seem from Mr. Beaumont's remarks that Huddersfield sends all its smoke into Halifax. Was this so? The Edinburgh power stations were growing bigger, but he thought they were not making as much dirt as formerly. However, the records taken by the gauges in Edinburgh showed a greater deposit. Could Dr. Owens state why this was?

BAILIE W. BROWNHILL SMITH (Scottish Branch) said that he wished to support what Dr. Des Voeux had said about the work of Dr. Owens. Glasgow, he thought, with its nine gauges, had the largest number of any city. Taking the average of the gauges gave a fair record of the city. The one quoted by Dr. Owens was not the best positional gauges; it was in fact one of the worst. He invited the members and delegates present to take a copy of the paper, by Mr. Harris, Chief Analyst of Glasgow, which had been read at a recent meeting of the Atmospheric Pollution Committee.

Dr. J. S. OWENS, replying to the discussion and questions, said that the cost of the Smoke Meter was 14 guineas. With regard to the query about a white background, one of the main advantages of the instrument was that it was used with the same background

as the smoke. The smoke issuing from the top of the chimney was viewed against its own background and matched with the instrument, viewing the same background. The advantage of this was obvious, since the background of the smoke might vary from time to time and was not comparable with that for example of a paper scale.

Replying to Mr. Beaumont, he said that it was not possible always to obtain ideal positions for gauges, but that the best available positions were selected. These were inspected by himself and were only used when the conditions were reasonably satisfactory.

In reply to Councillor Crawford, of Edinburgh, Dr. Owens said that the only explanation he could give of the fact that the gauges at Edinburgh were showing a higher deposit during 1933-34 than the average of the five years ending 31st March, 1932, was that the pollution of the air must be getting greater. There was no reason to suspect the gauges are giving incorrect results.

Referring to Mr. W. B. Smith's remarks, he agreed that Glasgow was very energetic in coping with the smoke problem, but it was not quite correct to say that it had as many or more gauges than London. Glasgow had nine deposit gauges, while London had thirteen.

THE EFFECTS OF SMOKE UPON VISIBILITY AND AVIATION.

By OLIVER COCHRAN, C.A.

I observe from the Journal of the Society that some years ago papers on "Atmospheric Pollution as affecting Visibility," and on "Visibility as affecting Aviation," were read by M. G. Bennett, M.Sc., and F. Entwistle, B.Sc., respectively, at an Annual Conference of the Society. For the purposes of the present paper, the subjects of these two papers have been combined, probably on the grounds that Visibility and Aviation are almost inseparable, and that any discourse on one inevitably involves the other. The time at my disposal for dealing with each of these subjects being thereby reduced by one half, I crave your indulgence if I appear to be unusually brief in discussing any specific topic. That smoke has an adverse effect upon the clarity with which we see a distant object is, I think you will agree, a commonly accepted fact, particularly by those of us who have flown or climbed to some eminence—no matter how small, but the great extent to which the limits of our observation are affected by this smoke nuisance and the natural phenomena associated with the process of smoke pollution are not matters of such common knowledge. We who are actively engaged in Aviation are brought daily into personal contact with the misconception harboured by the vast majority of the general public that smoke has as little effect upon our flying activities as it has on our motoring activities. Owing to its three-dimensional nature, aviation is so inter-related with visibility that a large staff is maintained by the Air Ministry throughout the country in forecasting each hour the conditions of visibility at any point.

Our time, therefore, will not be misspent in examining briefly the natural processes which take place when a volume of smoke is released into the atmosphere. Dust and smoke are collections of small separate particles floating in the air. In a dust the articles are relatively coarse, of varying sizes and consist of solid material, whilst in smoke they are not only of smaller dimensions but exhibit generally a greater uniformity; they may also be liquid as well as solid, as in oil or tar smoke. The two types are usually formed by the subdivision or disintegration of solid material by natural processes or artificial means, such as mechanical pulverisation; the latter by growth from the molecular state wither by condensation of vapour or by chemical reactions. The diameter of a small smoke particle is ten times smaller than that of a

dust particle, so that in still air, the dust settles rapidly while, in smoke, the particles remain in suspension for long periods.

I believe it has been calculated that about 20% of our industrial and domestic coal escapes in the form of smoke, dust, smuts and grit. If the visibility in an industrial area were only 20% less on the average than in the country, little would be said of smoke pollution from the aviation point of view. The difference, however, can be very great. A visibility of several miles can obtain in a district free from smoke pollution coincident with one of well under 1,000 yards in and near industrial areas.

The chief cause of smoke is well known to be low temperature combustion and the main remedy is a high furnace temperature which comes from the correct amount of air to the weight of coal. Of course, there are other contributory causes such as areas of furnaces, flues and chimneys being out of proportion, too thin fires, stoking too heavily or at the wrong time and poor chimney draughts.

Fog.

Passing to the meteorological aspect of smoke pollution, we can say that the presence of smoke particles is the cause of our densest fogs, certainly of those when visibility is in the region of 500 yards or less.

In dealing with visibility we are concerned only with the lowest layers of the atmosphere, those next the ground. Fog is essentially a surface phenomenon and it is usual to limit the term "fog" to a condition of atmospheric obscurity in which objects at a distance of one thousand yards are not visible. We can have fogs caused by particles of smoke held in suspension in the air or by particles of condensed moisture, in most cases by a combination of both, but the conditions for the formation of all kinds of fog are the same. We require (a) a cold surface giving rise to a stratification of the lower layers through cooling and (b) a very light wind. The stratification of the air prevents the smoke particles from being carried away vertically and the light wind prevents their horizontal transport too quickly.

It is estimated that between the hours of 6 a.m. and 9 a.m. daily during the winter months 200 tons of coal smoke are liberated over London. If the smoke is carried away or convection is active, the concentration of smoke does not exceed one milligramme per cubic metre, which is sufficient to produce the ordinary haze of a bright winter day. On a calm morning this smoke is not carried away and the concentration of the accumulation may reach four milligrams per cubic metre.

The true extent to which obscurity diminishes the trans-

parency of the air is best observed at sunset when the air is no longer directly illuminated by the sun. This is kept in mind when forecasting visibility in stable conditions—a decrease is given by sunset.

To show the effect of pollution and of humidity on visibility, Aitken gave a table of the mean limits of visibility for winds from different directions at Falkirk. West to North winds blow from regions having less than fifty inhabitants per square mile and Southerly and Easterly winds from regions with 100 to 12,000 people per square mile.

Depression of Wet Bulb.

Direction of Wind	2°	3°	4°	5°	6°	7°	8°F.
West to North ...	50	100	132	132	198	193	191 Miles
All other Directions	8	11	14	19	16	19	26 Miles

In London in winter, the average limit of visibility on a clear day is perhaps under a mile which is in marked contrast to the remarkably clear atmosphere prevailing in the warm air of an equatorial maritime climate. Incidentally, dust enhances the intensity and duration of twilight which would probably be different and much less bright if the upper air were free of dust and water particles.

Atmospheric pollution has a dominating effect on the persistence of fog in cities and industrial areas. A black or greyish-brown fog formed by the condensation of water vapour on the particles of smoke is very much more opaque than one which is white, i.e. largely devoid of smoke. The heat rays of the sun are unable to effect penetration to any great depth so that in a much polluted atmosphere the fog will often persist all day, while clearing in the surrounding country, perhaps by mid-day by the evaporation of the water-drops through heating. Thus, also, there is longer sunshine in the country than in the towns, especially in winter, by 20% to 40% in many cases. Indeed, Glasgow may be foggy all day in winter while the sun is shining brightly by early afternoon ten to twenty miles away.

Water Condensation.

Water vapour will only condense on particles of a suitable nature. The number of such condensation nuclei per c.c. of air varies widely from a few hundred in the Alps and in mid-ocean, to thousands in country districts and reaching 100,000 to 150,000 per c.c. above large cities like London, Glasgow or Manchester. It would appear that only dust particles chemically or physically hygroscopic actually function as condensation nuclei. These dust particles may be solid, for example, sodium chloride (from the evaporation of sea-spray) or sulphur trioxide, or liquid, such as hydrogen

peroxide, or gaseous, as ammonia or nitrogen peroxide. The last three are also produced by the direct action of sunlight.

In a moist atmosphere, the intensity of an existing obscurity is greatly increased by the condensation of water upon the suspended particles. Particles of a soluble salt will promote the condensation of water from such an atmosphere by reason of the lowered vapour pressure of water at their surfaces. Thus, at an ordinary temperature, water vapour will condense upon particles of common salt in an atmosphere of which the relative humidity is round 80%. The condensation of water vapour upon smoke particles for fog production, is largely due to the hygroscopic action of sulphur trioxide or of sulphates associated with the soot particles.

SO_3 is formed by the oxidation of SO_2 under the influence of ultra violet light and the SO_3 unites with the water vapour of the air to form H_2SO_4 . The hygroscopic nature of these acid particles promotes fog formation even in moderately moist air. Sulphur trioxide also retards evaporation of the water droplets of any fog if dissolved in them. Films of tarry oil which may form on water particles also prevent their evaporation. The amount of water vapour in the air varies from very much under $\frac{1}{2}\%$ by weight in desert regions to about 5% in warm moist regions.

Pure air is almost completely transparent to light of all wavelengths. This transparency is slightly reduced by the presence of water vapour and very much reduced by the presence of dust particles or water droplets. The diminished transparency is almost entirely due to the diffuse scattering of the incident light by the suspended particles. The composition of the light is altered, light of short wavelength being more completely scattered than that of longer wavelength. Hence, the visibility of a distant object, depending on the amount of contrast between it and its surroundings, is very much reduced by pollution in the air. Dust or water droplets formed on the hygroscopic nuclei, not only cuts off direct light from the object but also, by diffusely reflecting the sunlight that falls upon the suspended particles themselves, adds to the total amount of light received by the eye, so reducing the effective contrast.

Earlier in the paper, two conditions were given for fog formation (a) Stratification of the lowest layers and (b) a very light wind. The most obvious way to produce stratification of the lowest layers is to have them in contact with a cold surface. In this way, convection, which when operative, may distribute the pollution over a great vertical depth, is ruled out and turbulence near the ground is the only mechanical operation going on. Consequently, pollution is kept within

a rather thin layer, perhaps within a height varying anything up to 1,500 feet above the surface. Turbulence, caused through friction of the wind with the ground, ensures the mixing of the cold air next the ground with the warmer air immediately above. Cloud results from the mixing, if the surface air is cold enough. If there were no turbulence, or churning, there would be no mixing and therefore no cloud. The moisture, instead of being condensed in the air itself, would be deposited on the surface as dew. A light wind is therefore essential for fog formation.

It should be noted that the effect of cooling the air in the lowest layers by ground contact is to create what is called an inversion of temperature whereby temperature increases with height instead of decreasing as it does normally. Turbulence is limited to the layer affected by the temperature inversion and actually to the lower part of this layer. With ground fogs, inversion of temperatures start at or very near the surface, but in the type of fog which is usually called high fog, temperature shows a more or less normal rate of decrease, until perhaps a height of 2,000 feet is reached and then exhibits a sudden marked increase, often as much as 5°F. or 10°F. Condensation occurs therefore in a layer somewhat above the ground with, in addition, an accumulation of smoke particles. This condensation of moisture together with the pollution accumulation may produce a darkness at midday equal to that of night, certainly in the London area. For this type of fog the inversion of temperature is caused by warm air flowing on top of cold air, the surface of separation being called either a surface of discontinuity or a gliding surface. This condition is generally found in the margins of retreating anticyclones.

Local Circumstances.

Apart from certain meteorological conditions which primarily govern fog formation, its occurrence in any particular instance partly depends on local circumstances. Stations on the coast and not much above sea level have the lowest fog and mist frequency. Such freedom from fog may be partly attributable to the wind seldom falling light and partly to the small diurnal range of temperature. Western coastal stations are most frequently foggy in spring and summer while stations on the East and South coasts of the British Isles have a maximum fog frequency in autumn and winter. Some inland stations are subject most frequently to fog of the clear sky radiation type, i.e. Ross-on-Wye, and Renfrew, both lying in valleys and thus favourably situated for the drainage of chilled surface air.

The nature of the soil is also a cause of fog formation.

The frequency of fog at Farnborough in S.E. England is due to the soil being sandy and so responsible for a large diurnal range of temperature and a consequent formation of radiation fog at night. Again fog at a station may be due to its elevation vide Biggin Hill near Croydon or, in the case of a coast station, Beachy Head. The fog actually is low lying cloud.

It is not to be forgotten, however, that fog marches with atmospheric pollution and that industrial areas have the most frequent and densest fogs. Manchester has the unenviable distinction of recording a visibility of under two thousand yards on nearly one day in two. No other station gets anywhere near these figures.

Bad visibility affects all modes of travel and transport, whether on land, or sea or in the air, but, whereas, in the case of travel on land and sea, a thick fog is required before serious inconvenience is felt, the pilot of an aircraft, travelling perhaps at a speed of 150 miles per hour or more, is affected by conditions of visibility which are relatively unimportant to surface transport. Moreover, a fog may not only inconvenience, but may be a positive source of danger to an aircraft in flight, particularly if it envelops the aerodrome at which a landing has to be made.

Experiments with Direction-Finding Wireless Telegraphy and its general adoption by the Air Lines of the World are slowly but surely overcoming this danger as it affects aeroplanes carrying wireless equipment but for the large numbers of private and commercial craft which have no such aids to navigation, the fog menace still bulks at the largest impediment to progress towards universal flying.

In our discussions up to this point, we have been concerned mainly with the effects of smoke pollution at the point of creation, but there is ample evidence to show that smoke can be carried a considerable distance in sufficient quantities to affect visibility. To take an example almost at our doorstep, I have seen many occasions during an East wind when flying at Renfrew has been brought almost to a standstill through smoke haze drifting from Glasgow. I have flown frequently at Renfrew when the visibility to the East was a little over two miles while to the North, South and West it was almost unlimited.

Reference has already been made to an inversion of temperature. Generally, as the temperature lapse rate increases the smoke from industrial centres is carried down wind, in a gradually widening belt. With the prevailing south-west to west wind pilots flying between Scotland and the South of England frequently encounter smoke haze from the "Black

Country" when over Southern Yorkshire. Similarly, on the London-Continent route, pilots have on occasions met appreciable haze due to London smoke over the Channel some miles from the Kent coast. Under favourable conditions, thick smoke haze from the Midlands, reinforced by smoke from London is carried by winds from the North-West over South-East England and even over Northern France. With East winds, smoke from the industrial districts of Germany is carried over Southern England. These examples, taken from actual observations, might be repeated almost without end, but sufficient has been said to illustrate my point that smoke pollution is by no means local in its harmful effects.

The Position of Aerodromes.

With the rapid growth of air transport in this country there has arisen an urgent need for aerodromes in the vicinity of large towns. The foregoing considerations raise an important problem in regard to the siting of these aerodromes. Other things being equal, the normal situation for an aerodrome in this country would be to the west or south-west of the town. In selecting aerodrome sites it is customary to make a preliminary survey of alternative sites particularly from the point of view of fog prevalence, including the possible effect of industrial and domestic smoke. The penalty of failure to make these preliminary investigations has been brought home recently with telling effect to the townspeople of Manchester. The municipal aerodrome at Barton, on the north-west side of the city, on which approximately £100,000 has been spent, has been condemned by the Air Ministry on account of the abnormally large number of days in the year on which it is fog-bound. The city Corporation has recently decided to expend a further £170,000 in building a new aerodrome at Ringway on the south-west side of the city. It is quite possible also that in the not too distant future Croydon Aerodrome, on which untold wealth has been lavished may have to be abandoned on similar grounds in favour of a new aerodrome further south. But no matter what precautions are taken, there will always be occasions as long as the smoke nuisance persists, when visibility over even the most perfectly sited aerodrome is affected, since the wind does not blow consistently from one direction.

It is axiomatic that prevention is better than cure. Up to the present, the aviation industry has concerned itself with attempts at overcoming the fog nuisance by means of wireless, beacons and other ground signals. It would seem, however, as if the time had now come when its attention might be directed towards the partial or complete elimination of the smoke nuisance with ultimately much greater benefit to the

industry. Fog in the form of condensed moisture there will always be, but we have seen that such a fog or mist, as it might be more truly termed, is almost negligible in its harmful effects when compared with the black or yellow monstrosity resultant from smoke. Co-operation, therefore, between this Society and the Aviation Industry, with its vast resources must inevitably produce the results so greatly beneficial to all. No doubt advances to the other have been made by both parties long ere this, but at the risk of treading on ground which has already been well explored, I would earnestly urge that no effort be spared by both to consummate a unison of parties whose interests are so closely related.

In conclusion, I wish to acknowledge my indebtedness to W. E. Gibbs, D.Sc., R. Whytlaw-Gray, Ph.D., and W. J. Grassick, of the Meteorological Office, Paisley, for much of the information contained in this paper.

DISCUSSION.

PROFESSOR CURRIE, in inviting discussion, said that the air of Glasgow was made worse by the vapourizing of water that made visibility so poor. This made fog, but fog could be improved by not emitting smoke into it. In the future smoky towns would lose their chance of becoming great aviation centres, and counties over which flying took place would also be avoided.

Dr. J. S. OWENS said that the densest fogs were due to water vapour. On approaching a town the visibility was increased. Water fogs were condensed by the heat of the city and thus visibility was increased, but the fog became yellow.

COUNCILLOR C. E. KEENE (Leicester) welcomed the paper and hoped that the author was the first of a long line of young men interested in flying who would do what they could to impress the importance of a clear atmosphere upon other flyers. He urged that something should be done to bring the importance of a clean atmosphere to the notice of the Government, and suggested that the aircraft manufacturers should, in their own interests, support organizations such as the National Smoke Abatement Society.

COUNCILLOR T. KNIGHTS (Hackney) said that in a place like London, where so much business was now conducted by air, much depended on the absence of fog. The possibility in the near future of an increase in the number of aircraft, including the suggested delivery of mails by autogyro on to the roofs of buildings—which had already been surveyed—made the subject of great importance; and if the Society could by its efforts induce the coal consumer to see how essential it was, not only from a visibility point of view, but also from a health point of view, then black and yellow fogs could be abolished.

Dr. H. A. DES VOEUX spoke of an experience he once had of going from the country to the city, and finding that the visibility in the city was much better than that of the country. The heat of the city reduced the density and cleared away the water fog.

Dr. A. J. SHINNIE (Westminster) said that a previous speaker had emphasized that in the event of war, which he trusted was extremely remote, he, the speaker, had affirmed that it would be greatly to the disadvantage of the air forces of this country if in the event of hostile invasion they had to carry out manoeuvres in an atmosphere of fog and smoke. Dr. Shinnie felt it right to bring to the notice of the conference that this would cut both ways. He reminded them of the inestimable use by the Navy of smoke clouds and pointed out that if our aviators were handicapped by fog the operations of the enemy would be equally hampered. Therefore if it was intended to stir up the manufacturers to the cause of smoke abatement, the issue should not be lost sight of that their co-operation might also be obtained not only in the abolition of conditions of obscurity, but also in encouraging them.

BAILLIE W. BROWNHILL SMITH (Scottish Branch) spoke of the effects of the smoke fog of 1909, when the deaths due to respiratory disease rose from the October average of 35 (or 2.1 per 1,000) to 233 (or 13.9 per 1,000) for the week ending November 27th. During the same week the deaths in seven small towns round Glasgow rose from 31 to 93. Fog in the country soon cleared away because the sun vaporized the water particles, but the city fog, containing carbon and tar, formed a coating round the water particles and prevented vaporization. In 1909 the dense fog experienced in Glasgow was due to the water particles having a coating of tarry oil. London, being more congested, produced more heat to evaporate the water.

Mr. R. D. HARDY (British Coal Distillation Ltd.) said that he appreciated the splendid work that had been done by the Society and the power which it now exerted nationally. It appeared to him that they acted in a similar capacity to a consulting physician; they had diagnosed the serious position of the "patient" from time to time most accurately and they had also provided a remedy for the disease. It should be realized by now that the thinking part of the nation appreciates this weakness, and is fully conscious of the nature of the remedy. To put it in other words, they fully understood that there were millions of open fires in the country, which, notwithstanding the supplies of electricity and gas, would continue to be open fires, and they realized that what was required was a sufficient supply of good smokeless fuel. There was a big national need and the nation was conscious of it, but the supply was left to about half-a-dozen individual concerns, or companies, without any financial backing or support. They, as manufacturers of smokeless fuel, would ultimately be able to supply this need, but as had been seen in one prominent

case, it had taken over 25 years and cost over a million pounds for one concern to become successful.

Mr. Hardy thought that the Society should turn its attention to bringing its great experience and influence to bear upon the Government or the nation to help forward the movement. A comparatively small backing by the Government would achieve the object. What was needed was finance for about five or six large plants, and if the Government would guarantee the interest on two million pounds for ten years, which at the worst would only be a possible risk of one hundred thousand pounds per annum, the battle would be won.

When these plants were in operation any amount of capital would be forthcoming from the ordinary commercial channels for the erection of all the requisite plants, without any Government help. This, if carried to its logical conclusion, would quickly achieve the object of the Society, and incidentally be the financial salvation of many collieries and produce large quantities of oil from their own coal mines, in place of oil which is now imported.

Mr. **ARNOLD MARSH** said that the Society wished that there could be co-operation with the air people as Mr. Cochran had suggested. They also felt that, in their own interests, the operating and manufacturing concerns should support the Society in its work. Councillor Keene had said he did not think that helped us even to the extent of one guinea. That was quite true, for after the last papers on the same subject by Bennett and Entwistle at the Leicester Conference, copies of the paper had been sent to all operating and manufacturing firms, and to the flying clubs, but no response whatsoever had been received. There were not even expressions of sympathy with, and of moral support of, the work the Society was doing in improving visibility and therefore flying conditions.

Mr. **OLIVER COCHRAN**, replying to the discussion, said that smoke abatement would ultimately be achieved as the outcome of the efforts to promote aviation and secure good visibility.

The type of fog found in London, as explained by Dr. Owens, was also experienced by Glasgow. A smoke pall 1,000 to 2,000 feet above Glasgow prevented the heat rays from penetrating and thus condensing the vapour in the city to make visibility greater. The blanket of smoke lying over the towns and cities was the worst enemy of the pilot. By means of wireless he could tell when he was over an aerodrome, even when in very thick fog.

Mr. Cochran continued by explaining the way by which a wireless operator on the aerodrome could guide the movements of a pilot and so assist his landing.

He thought that the National Smoke Abatement Society had not approached the proper people in the aviation industry. The people to approach were the operating companies, such as Imperial Airways, and similar airline companies. The companies operating

and directing flying were more interested in the abatement of smoke than were the manufacturing companies. If they approached these companies they would, he felt sure, receive very favourable consideration, and if they could get the Air Ministry interested in the subject they would have overcome nine-tenths of the difficulties of getting aviation interested in smoke abatement.

Friday afternoon, September 28th Conference, 2nd (Scottish Branch) Session.

Chairman: H. A. DES VOEUX, M.D.

**THE EFFECT OF A SMOKE LADEN ATMOSPHERE
ON HORTICULTURE.**

By WM. D. BESANT, Director of Parks, Glasgow.

Plant cultivation in towns and cities, particularly in manufacturing centres, presents many difficulties, and without question the greatest of all is the fight against the polluted atmosphere—a fight for life it really is in the case of many plants. Anyone interested in Horticulture or Arboriculture must view with deep regret the unhealthy appearance of many of our plants in the city. Unfortunately in the large manufacturing cities of our country the air is charged with soot emitted from factory and domestic chimneys, and this condition is not confined just within the city but extends for considerable distances beyond the boundaries.

By close observation one can easily detect the effects of a polluted atmosphere as one approaches nearer and nearer to a large manufacturing city. Trees well away from the city are vigorous and clean. As one enters the smoky belt surrounding the city the trees become less vigorous and are grimy, until, within the city itself many species disappear entirely, being quite unable to survive in the obnoxious atmosphere. Those species which do survive are mostly stunted specimens and never have the clean, healthy appearance of their country cousins.

As I have just mentioned the air in and around large cities in the manufacturing districts of the country is charged with soot in either a fine or coarse state of division. The soot consists chiefly of carbon, and along with it various compounds of an oily nature formed in the combustion of the fuel. All of you will be familiar with the black coating that settles on everything from an atmosphere polluted with smoke. Fresh air is all important to the good health of human beings, and as the vegetable kingdom is in many respects similar to the animal world, fresh air is just as important to plant life. So far as plant life is concerned, this coating upon the leaves and twigs is highly injurious; it clogs up the stomata or small openings through which air passes into the tissues of the plant; in other words, it partially suffocates the plant by restricting its power of breathing. Fortunately nature has protected plants to some extent, as these pores are placed on

the under side of the leaves. Were it not so, and the breathing pores were on the upper side of the leaf, then in our atmosphere they would become completely choked. Not only does it restrict the breathing power, but it also hinders the leaves from performing properly other functions necessary to the health of the plant. It excludes light from the leaves, which causes them to become unhealthy in themselves and therefore unable to efficiently assist in providing the food required for the well-being of the plant. The result under present-day conditions in our large cities is that trees, shrubs, and other plants can only withstand the atmosphere for a limited time and periodically have to be replaced by sturdy country grown specimens. The sickly plants often when transferred to the fresh air of the Nursery, gradually regain their former vigour. Soot in itself is not so detrimental as one might expect to plant life, but it is the many harmful substances which it carries with it that do most of the mischief.

The Action of Sulphur.

The real danger to plants in cities, and manufacturing cities in particular, arises from the presence in the gases formed during combustion of poisonous products, of which sulphurous acid gas is by far the worst. Its presence, of course, is due to the existence of sulphur in coal as an impurity. The leaves of some plants show traces of poisoning by sulphurous acid gas when the proportion in the atmosphere is as low as 1 in 1,000,000 parts, and it has been found that even clover and grasses are killed when exposed to a proportion of 1 in 40,000 parts. These experiments necessarily have been carried out with plants in confined air under bell glasses, and it has to be remembered that, in the open air, plants are not always exposed to the continuous action of the gas; if they were, then the amount of gas occasionally contained in the air would make plant life almost impossible. It has been found that plants poisoned by sulphurous acid gas show at first translucent spots between the veins of the leaves. These spots gradually become dull green, then brown, and eventually dry and withered. Along the veins extend green borders which form a network in the brown dry leaves. This green network is an indication of the cause of harm, and chemical analysis of the leaves affords a proof of the presence of sulphur in excess and confirms the indication given by the colour.

Herbaceous plants really suffer more than ordinary deciduous trees, and fortunately during the winter months when probably the atmosphere in manufacturing cities is at its worst, the least amount of damage is done for the simple reason that growth to a great extent is dormant. Plants in

conservatories during the winter suffer very considerably, in fact it has been found practically impossible to grow many of the tender leaved subjects. After a severe fog of the sooty variety, whole batches of plants such as Begonias become almost entirely defoliated; others which are winter blooming, such as the Slipper Orchids, have their flowers reduced to a mass of pulp in a single day of severe fog. It is frequently remarked that everything which is said to-day has been said before, and said much better by the great masters of English Literature. A recent reprint of John Evelyn's "Fumifugium" illustrates this point. The hygienic blessings of sunlight to nature is not a recent discovery, and the crusade for the abolition of smoke is not a twentieth century one. Evelyn said in 1661 almost all that is said to-day. He refers to the smoke pall as that "hellish and dismal cloud of sea coal with its filthy vapour corrupting the lungs." He was a Londoner, full of pride in his city, but full of contempt for the pernicious smoke which sullied all her glories. In these far off days Evelyn's suggested remedy may have been somewhat different to that which is advocated to-day. His remedy was to remove all factories to the outskirts of the city, and on all vacant ground in and near the city to plant trees and shrubs bordered with sweet smelling flowers. It was realized hundreds of years ago that smoke was detrimental to plant life, and until we can rid our cities of smoke and pernicious gases in the atmosphere it will be impossible to display many of the beauties in plant life which nature provides in abundance.

The Glasgow Parks.

An inspection of the Public Parks in Glasgow illustrates conclusively that atmosphere has a very decided bearing on plant culture. In all our city parks the old established trees are rapidly dying out, particularly in such as Tollcross and Kelvingrove; whilst trees of a similar age and even older in the outlying parks such as Loch Lomond Park and King's Park are still stalwart giants full of vigour. It is noticeable that generally plants in south and south-west districts of the city are healthier than those in the north and north-east—accounted for, no doubt, by the fact that the prevailing wind from south-west carries the fumes with it and they are largely deposited in the north and north-east. In one park, namely, Glenconner, situated in the Garngad district and in close proximity to copper works we have found it impossible to grow anything in the nature of trees and shrubs, and practically every variety which had the slightest hope of surviving has been tried; even grass ekes out a miserable existence. From the horticultural point of view, I would say without hesitation, this is the worst atmosphere in the city.

I have dealt almost entirely with the presence of soot and poisonous gases in the atmosphere, but another aspect of the soot deposit must not be overlooked. All horticulturists know the effect of fresh soot on soil. An over-application of soot has the effect of clogging the soil and making it unhealthy and sour, therefore, with a stiff clay soil such as we have in Glasgow, much harm is done to vegetation by the annual soot deposit which rapidly clogs the soil, thus preventing aeration, making the rooting medium of all plants unpalatable to them, causing them to gradually fall into bad health and eventually die. This can be counteracted to some extent, of course, by methods of cultivating the soil.

A more recent enemy to plant life in our cities has arrived in the form of motor traction. The deadly carbon monoxide which is emitted from the exhaust of motor cars must have some effect on vegetation in a city like Glasgow with the large number of motor vehicles in use daily. One has only to note the damage done to a hedge or any other plant which comes in contact with the fumes from a motor exhaust, to realize that here we have another enemy of the city gardener.

Lists of plants are at all times wearing to the listener, but we find that some species of trees and shrubs withstand the atmospheric conditions better than others. Coniferous trees, such as Pines, Cupressus, etc., simply refuse to grow, whilst Planes, Elms and Pyrus are amongst the most tolerant. The hardier ever-green shrubs do fairly well, such as Rhododendrons, Olearia, Aucuba, Privet, etc. The shrubs at least survive but they do not blossom forth as they do in a pure atmosphere, and certainly they always look rather dejected and down-hearted with their black grubby leaves instead of the clean, shiny leaves which remind one of the smiling face of a healthy child. To realize the amount of filth which clings to the leaves and twigs of plants in our city, one has only to notice any of our Park employees at the end of a day's work in a shrub border. They finish the day as black as a coal miner or chimney sweep. When the pernicious smoke is abolished our beloved plants will get a place in the sun and a promise of health.

DISCUSSION.

Dr. H. A. DES VOEUX related how he had tried to grow tulip bulbs in his city garden. The first year they all came up, but the second year they were only a score or so out of the five hundred. He changed the soil, getting fresh from the country, where the plants had been growing, but they still would not flower. Finally they were taken back to the country, and after a year practically all recovered

and flowered freely. Children suffered the same way as plants. They became poor and rickety.

ALDERMAN WILL MELLAND (Hon. Treasurer) said that the replacement of plants growing in the city must mean considerable extra cost to the local authority concerned. Could Mr. Besant tell them the extra cost entailed by the filthy state of the atmosphere in Glasgow, as regards the whole park system, for one, or for a group of parks?

On the following Wednesday in the Manchester City Council a resolution would be moved which would ask the City Council to go into the question of reducing the cost of gas and electricity, which were both municipal, in order to encourage their use by a reduction of price. Possibly it might result in a loss to the gas and electricity departments, but it would be repaid by the purification of the atmosphere. If they could have some figures showing what they would gain (Manchester owned 74 parks) it would have some weight in persuading the Council to adopt the suggestion, as it would then be possible to say how many thousands of pounds could be saved.

Mr. BESANT said that he could not give any actual figures, but the loss was shown by the fact that the plants in George Square, and elsewhere, had to be renewed every three years.

COUNCILLOR T. KNIGHTS (Hackney) asked whether the water used for the plants grown at Loch Lomond and in Glasgow, of which they had been shown specimens, was the same in both cases. Might not such a difference be a factor?

Mr. BESANT said that there was very little difference in the water used.

COUNCILLOR G. W. CRAWFORD (Heriot-Watt College, Edinburgh) said he had been particularly struck with Mr. Besant's practical demonstration, and especially with the reply to his question that they were not selected specimens but fair samples of identical trees and shrubs grown in suitable soils on the banks of Loch Lomond and in the city of Glasgow. Few people realized what a deleterious effect sulphur fumes had on plant life. He noticed this in connection with a large public works where the untreated products of raw coal combustion were permitted to escape up the chimneys. There had been an extension and the deterioration was most marked in the vegetation opposite the new boilers which were worked at a higher thermal efficiency. The gases, being colder, sank rapidly and made their presence visible. While sulphur dioxide was most destructive to plant life it could be used in small quantities by human beings as a disinfectant, and was also used in such foods as sausages as a preservative. On the other hand carbon dioxide showed its bad effects on human beings most markedly.

Dr. B. WYLAM (Department of Health for Scotland) said that Mr. Besant had referred to the damage done to vegetation by sulphur

gases in the atmosphere. Some short time ago he had a very good illustration of the harmful effects of sulphur dioxide upon plants and trees. In a small town in Scotland an accident occurred in sulphuric works whereby a large amount of sulphur dioxide was suddenly emitted. The matter was referred to him for investigation and he found that the passage of the gas had left a definite track over a number of gardens. Many plants were entirely destroyed whilst in other cases the destruction was only partial. Some plants, for instance, rhubarb, had large brown patches on their leaves; sweet-peas had had their leaves completely withered but the flowers were unaffected. Many trees were also damaged, particularly laburnum and sycamore. The leaves were withered at the edges and the trees appeared to have been suddenly blighted. He observed one remarkable thing—in a garden an apple and a pear tree were in close proximity and the branches were actually intertwined. The pear was very badly withered whilst the apple was unaffected. A large horse-chestnut in the direct path of the gas was badly damaged. On the day after the accident it showed signs of withering. A few days later the whole of the leaves were completely brown and at the end of about a fortnight the tree was entirely denuded of leaf.

Mr. R. H. CLAYTON spoke of the harm done to fields bordering roads, owing to the harmful effects of the exhaust fumes from passing motor vehicles.

COUNCILLOR C. E. KEENE (Leicester) asked if they could not encourage the people to burn less raw coal by showing them the effects of smoke in the cities? Would it not be possible to distribute literature in the parks, public places, and elsewhere where people could see for themselves the results of their burning raw coal?

Mr. CHARLES GANDY (Manchester Branch) congratulated Mr. Besant on the clear evidence of the harmful effects of smoke given by the exhibits of trees and shrubs, and suggested that it would be useful if a similar object lesson could be given to the public by showing such exhibits or others like them suitably labelled in a corner of the public parks or in one of the empty shop windows now to be found in any city.

Dr. A. J. SHINNIE (Westminster) thought that other factors besides pollution of the air should be taken into consideration in examining the state of plants. There was, for instance, the difference in the amount of sunlight in the City Hall area as compared with Loch Lomond; and also the rain in the city area would be highly acid, and this in itself would have a deleterious effect on plant life.

Dr. Shinnie concluded by paying a tribute to the Glasgow Corporation as an authority acting in the work of smoke abatement. There was no more eager and earnest local authority in the country in this sphere of public work, and he alluded to the value of the Medical Officer of Health's, Dr. McGregor's, Annual Report in dealing

with these questions. When preparing evidence for the Fulham Power Station Inquiry in which certain of the London authorities petitioned the Electricity Commissioners against the construction of this power station on the possible damage to health and amenities, he found Dr. McGregor's report one of the few sources of accurate information from which to base a report on health grounds.

PROVOST MACINTOSH (Stirling) said that in regard to vegetable and plant life as well as human life, fresh air was essential for healthy vigour; and there should not be overcrowding in the soil in plant life, nor with persons in dwelling houses, if they were to live and thrive.

Mr. E. W. NICOL (London and Counties Coke Association), said that on his return to Glasgow for the Conference, he was told that air was comparatively pure during the evenings and on Sundays. Personal observation had proved this to be correct; and it tended to disprove the suggestion that atmospheric pollution was mainly due to domestic smoke. It was more than 34 years since he had resided in Glasgow; and his recollection of the smoke-polluted condition of the atmosphere towards the end of the last century was still very vivid. Allowing for the depression in the heavy industries in Glasgow, the improvement at the present time was most apparent. One had only to examine the charming gardens in the Corporation's new King's Park, and other housing developments, to realize the progress that had been made in suppressing smoke emission. This was said to be due mainly to the increased use of gas as fuel for cooking and heating. He found, on enquiry in Glasgow, that the prejudice against gas coke as fuel—prejudice based probably upon lack of knowledge—was still deeply rooted. In the London district this prejudice had largely been broken down. Of the 18 million tons of coal used annually 6 million tons were carbonized and rendered smokeless at the gas works. The resultant 3 million tons of gas coke were used largely, and to an ever increasing extent, for domestic heating purposes—in open firegrates and domestic hot water boilers, with a corresponding diminution in the use of raw coal and smoke emission. He had seen recently an analysis of the Glasgow Corporation gas coke. It was of relatively high quality and suitable for domestic heating purposes. Similar coke was used in London in open fires, in hospital wards, for central heating and steam raising, on its superior economic merits. Everyone was perfectly familiar with the baneful effect of smoke pollution upon plant life, as Mr. Besant had so ably demonstrated and also upon public health and child life, as a result of the Society's propaganda. What was wanted was practical remedies; and he hoped that future conferences of the Society would be devoted entirely to the discussion of ways and means of preventing the formation and emission of coal smoke.

ALDERMAN WADDINGTON (Halifax) said that he had been impressed by the paper and by the demonstration of plants, and

wanted to know what was really the remedy for the smoky atmosphere? What should be done in order that both plants and people in our towns could live better? What should he report to his Council, and what steps should he propose be taken?

Mr. DIBBLIN said that the previous speaker had asked what he should report to his Council? What had he learned at this Conference which would be of use to his district?

Example was better than precept. He would tell Alderman Waddington what was done in his district.

By talking to the Engineer of a very large works that periodically caused them much trouble by smoke emission, he induced him to change from coal to coke. At first this was not very successful but by increasing the spaces between the fire bars from $\frac{3}{4}$ in. to $\frac{1}{2}$ in. the necessary increased draught was obtained. That firm had used coke ever since and had not been the source of any further complaint.

Again since 1929 about 90% of the small laundries mostly using vertical boilers had been converted to the use of coke with the result that smoke nuisances did not now arise on those premises.

He would suggest that their friend got the Inspector to give advice and use his persuasive powers with the factory owners along those lines, when he would find his troubles would be very materially reduced.

COUNCILLOR ALEX MUNRO (Glasgow) said that he would give some advice to Alderman Waddington. He should tell the people of Halifax to burn good gas, not merely cheap gas. They should reduce the price of electricity. In Glasgow they were making an effort to help the people to make less smoke. They should lower the prices of gas and electricity and encourage the people to burn them.

"Nature is beautiful and rejoices in her loveliness."

"And only man is vile."

W. BROWNHILL SMITH, M.V.O., D.L., Glasgow.

The processes of Nature are clean and health-giving, and so long as man depended on the forces of Nature for heat and power all was well.

The Sun, giving heat and light, is beautiful. The rivers and waterfalls turning mill wheels are things of beauty. The mill with its sails driven round by the power of the wind is picturesque. Many an artist has included a windmill in a landscape as an enhancement, but many a fine view has not been chosen as the subject for a picture because it was defiled by chimney stalks pouring their filth over the scene; and this because man has been too slovenly in his habits to learn enough of Nature's laws to conduct his affairs properly.

When he found that he required more power than that supplied by wind and water he discovered that Nature had stored up in the earth coal, which James Watt showed could be converted into power by burning it under a boiler to convert water into steam at pressure; but here men did not study the laws of natural science. Had they done so they would have found that to consume 1-lb. of coal would require about 11-lbs. of air—a volume of 138 cubic feet. They did not make this calculation, but often just shovelled coal into the furnace, where it did not get enough air for complete combustion, and what did not get burned was distilled, and escaped into the air in the form of soot and tarry-oil; its value as fuel being lost to the owner of the boiler, and what is infinitely worse, causing injury to health and property.

In the domestic fire the temperature is not always high enough to ensure complete combustion of all the coal put into the grate. The Smoke Abatement Committee's report said:—

"at least 6 per cent. of the bituminous coal ordinarily burned in domestic fireplaces escapes unconsumed into the atmosphere as soot. Taking $40\frac{1}{2}$ million tons as the amount of coal burned annually in the United Kingdom in its natural condition, for domestic purposes, the loss amounts to 2,430,000 tons. That is to say, nearly $2\frac{1}{2}$ million tons of soot escape into and pollute the atmosphere every year from domestic fireplaces alone."

It is evident that coal is of too complex a composition to be burned in its raw state, so to get the greatest efficiency and to suit the various methods of heating, we must split it up

into three types of fuel, a solid, a liquid, and a gas, each useful in its own way.

When coal is put into a vessel and heated gradually, it first gives off the water it contains; then as the temperature rises, changes begin to take place and gases are evolved. Those coming off first, contain the vapours of light oils that boil at low temperatures, but as the heat increases, heavier oils, of higher boiling points, are liberated, and gas and oils continue to come off, up to a low red heat, about 500°C . If these oily vapours are carried off and escape from the retort at the temperature at which each of them is evolved, when they cool and condense we get what are called true primary tars, but if they are over heated before they escape from the retort then they are decomposed; part being converted into gas, part into a different type of oil, and part into carbon or soot. If we want to get the greatest quantity of oil out of our coal, and those oils that are of most value, we must get them in this way, so that they shall not be overheated and partially destroyed.

Overheating also has a bad effect on the coke, which is the solid matter left after the volatiles (oils and gas) have escaped. There is a critical temperature, somewhere a little over 700°C , which, as in the case of the oils, should not be exceeded. When the coal has not been heated beyond that temperature it is found that the coke from it ignites and burns about as easily as raw coal. It is an ideal fuel, being, like wood charcoal, practically pure carbon, with a certain percentage of ash, which is inert. But if the temperature in the retort is raised above that critical point, the ash does not remain inert, but seems in some way to combine with the coke and slightly vitrify it, making it difficult to ignite and sustain combustion, in ordinary grates and furnaces.

Here again is an example of man's slovenly way of doing things without observing, and working in accordance with, nature's chemical and physical laws.

If the valuable oils, that we can get from our British coal instead of buying from abroad, are obtainable only at certain temperatures, why destroy them by overheating?

If the easy-burning property of coke is destroyed by a high temperature, why make it so hot? When coal reaches a temperature of about 700°C everything volatile has been extracted from it; the process of carbonization is finished. Then why heat up to 1400° as is done in the gas works?

The only way to stop smoke is to stop burning raw coal, and the only way to do that is to provide substances that are better than coal. In the case of solid fuel that was done a hundred and twenty years ago.

In "A Practical Treatise on Gas-Light," by Frederick Accum, published in 1813, it says—"It is sufficiently known that coke is a more suitable fuel than the coal from which it is obtained. Coke is decidedly superior to coal for all domestic and, more especially, culinary purposes; the heat which it throws out being more uniform, more intense and more durable. No flame, indeed, accompanies it, and it seldom needs the application of the poker—that specific for the 'ennui' of Englishmen—but these deficiencies are more than balanced by the valuable property of emitting no sparks, of giving more heat, and burning free from dust and smoke.

"That coke must give out more heat during its combustion than coal will at once become obvious when we consider that the quantity of matter which, in the combustion of coal, is changed from a solid to a state of elastic fluidity must necessarily carry off a portion of caloric which then becomes converted in a latent state without producing heat, whilst the glow of the coke radiates caloric with an intensity unimpaired by any demand of this kind. It is thus that coke always gives out a more steady, a most lasting, and a more intense heat."

That it was considered more valuable than coal is shown by a balance-sheet of the cost of making gas in a small plant installed in Manchester in 1813, which states that the Cannel coal used for making the gas cost 22/6 per ton, and the ordinary coal used for firing the retorts cost 10/- per ton, but the coke made in the plant sold for 26/6 per ton.

This exactly describes the coke made to-day at low temperature. Iron retorts were used then, and at that early time, when experimenters were feeling their way, the temperature would not be raised higher than was just necessary to remove the volatile constituents from the coal. Such coke can be burned in any grate or furnace—domestic or industrial—without alteration, and can be used wherever a solid fuel is desired. It is not merely a substitute for coal, but actually a more efficient fuel, and none escapes unconsumed; the flues and chimney being always free of soot, never require cleaning, and above all there is no smoke.

If liquid fuels are required for heat and power they can be obtained from these low-temperature oils.

The Royal Commission on the Coal Industry (1925) in the section of their Report dealing with low temperature processes, said:—

"The nation would obtain from its own soil a considerable supply of oil for use in internal combustion engines and other purposes for which natural oils are now imported."

"If it were possible to subject to this process the bulk of the 147,000,000 tons of coal now consumed annually in the raw state, the greater part, at least, of our present requirements could be supplied from home sources instead of being imported from abroad."

About the third product, Gas, the Fuel Research Board, in a report on gas standards published by the Department of Scientific and Industrial Research in 1922, said:—

"The sheet anchor of the gas industry in the future must necessarily be its possession of the cheapest known means of distributing potential heat energy in a convenient form. For lighting and for power production the electric supply of the future may seriously contest the field with the producers of gas, but for the supply of heat, gaseous fuel ought to remain supreme, if its production and use are developed on sound lines."

It seems strange that the gas undertakings have never attempted to carry out this suggestion and create new business for themselves. Gas is an ideal fuel in the house and in the workshop. It is suitable for the fireplaces in the palace and in the humblest dwelling. The housewife ought to be able to get a supply of heat as easily as the supply of water, simply by turning on a tap.

In warehouses and other commercial buildings with central heating the boilers should be fired by gas, the temperature under thermostatic control. In most manufacturing processes gas should supply the heat.

For lighting, gas is obsolete; electricity is the ideal for that purpose; also for power transmission; but for the production of power gas could hold a place—under proper conditions—in preference to raw coal.

But to bring all this about there must be change of method, both in production and distribution.

The carbonization of coal must be freed from the trammels that surround it; monopoly must be cleared away. Every gas undertaking, whether owned by a local authority or a company, has a monopoly in its own area; there is absolutely no incentive to improve. In this area there are three local authority gas undertakings adjoining one another; the average price of gas in one is 5.3d., in another 8d., and in the third 1/3d. per therm!

In 1917 the Board of Trade appointed a committee "To consider and report what steps should be taken, whether by legislation or otherwise, to insure that there shall be an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly

industries which depend upon a cheap supply of power for their development." On its recommendation were framed the Electricity Acts, which provided that electricity should be generated only where it could be done under the most favourable conditions and at the lowest possible cost, and put into a common pool, from which it could be distributed impartially.

The result has been an enormous increase in the use of electricity and a great reduction in cost, while thousands of factory chimneys have been put out of action and many houses too are smokeless.

What freedom of interchange there is for electricity! Current generated by water power at Rannoch is sold in Dundee and distributed to many smaller places on the route, and it may even reach Glasgow occasionally. Current generated in Glasgow may be distributed in Edinburgh area, and vice versa. Current generated by water power in Galloway will supply not only the South of Scotland, but will go into central Scotland and North-West England.

The installation of gas grids, in suitable areas, presents no more difficulty, probably less, than electricity grids, and the chances of an increased consumption of gas are even greater than that of electricity. Under the conditions I have described gas could be made and sold at such lower prices as would increase its use.

At fourpence a therm it could supply all the heat required for domestic purposes as cheaply as solid fuel; it would pay to instal and use gas fires in every room in a house.

At threepence it would be cheaper than coal for many industries, and for power it could compete with electricity. Gas at threepence per therm would be equal to electricity at 0.4d. per unit, for power.

At twopence it could be used for nearly all metal and ceramic industries and for power.

From twopence to 1.2d. per therm, it could be used in the steel industry.

At one penny per therm it could be used to generate electricity.

What a prospect this opens out for the gas industry! Instead of carbonizing only about 17 million tons of coal per annum, in quite a few years they might be putting through about 130 million tons, nay, far more, because as the price of gas is lowered a greater quantity would be sold; with an easy-burning smokeless fuel, beside that used at home the demand for export would be greatly increase; for use on steamships it could be pulverized at the gasworks, and carried in the bunkers in bulk, without the danger of spontaneous combustion, as in the case of coal.

The oil could be used in oil-burning steamers, and the gas undertakings, instead of being buyers of oil for carburetting purposes, as they are now, would be sellers of oil.

All this would increase the demand for coal and provide more work for the miners.

But what interests us is the certainty that in the near future we would see not only the beauties of Nature undefiled, but in our cities we would see the grandeur and beauty of man's art and skill, as shown in the architecture of our buildings, which would retain for all time the delicate tints of the stone and the fine details of the mouldings and carving.

As in Rome we see the Facade and Colonnade of St. Peter's much as they looked 300 years ago, and in Florence the Duomo and Campanile just as they appeared about 500 years ago, so would those who follow us here see the buildings that they erect remain clean, and not filthy-coated as those we see around us now, that were built only 40 or 50 years ago.

And they will know that their lungs will be clean and red coloured, not the hideous soot-blackened objects that we breathe through.

Man and his buildings would then be clean, not vile.

DISCUSSION.

E. M. HOOD (British Electrical Development Association) said that in a general way gas and electricity might be fighting a joint battle against atmospheric pollution. This "companionship in arms" had been recognized by the National Smoke Abatement Society, because at the Sheffield Conference last year a resolution was adopted recommending, among other things, "That appliances for the use of gas and electricity should be installed extensively and their use encouraged."

He took that resolution as his justification on the score of relevancy for adding a few comments to the paper they had just heard, because it seemed to him that in listening to the paper, one would assume that the universal adoption of gas alone would be sufficient to solve the problem.

Quoting from the paper, Mr. Hood read: "At 4d. a therm it could supply all heating required for domestic purposes. At 3d. it would be cheaper than coal for many industries. At 2d. it could be used for nearly all metal industries and for power. From 2d. to 1.2d. it could be used for the steel industry. At 1d. per therm it could be used to generate electricity."

Generate electricity for what? There did not seem anything left for electricity to do, so why generate it at all? A clue to the answer was to be found in an earlier part of the paper, in which it was said that for lighting gas was obsolete, and that electricity was the ideal for the purpose.

Why should such a definite conclusion be arrived at? Without going into relative figures of efficiency running into three places of decimals, a pretty good rule of thumb test was to imagine asking an ordinary individual whether he would have gas or electricity for lighting his house, if they were both supplied free of charge. The vote would certainly go to the electricity, and if one went further and asked this hypothetical man why the preference, the answer would certainly not be that it gave a better light but that the absence of a naked flame made it safer, cleaner, and more convenient.

That, he thought, gave the clue to the demand for electricity, not only for lighting, but, he suggested, for heating, cooking, and other domestic uses.

Whenever there was combustion there were products of combustion, and one recollected blackened ceiling above open gas flames, just as much as with oil lamps and candles. He suggested the same consideration applied where the gas flame was connected with a fire for heating purposes, or a stove for cooking purposes.

Anyway, the great British public seemed to think so, because the Electricity Department of the city of Glasgow kept connecting some hundreds of electric cookers in dwelling houses every year. The consumption of electricity in the country was up 50% compared with 1927. The number of units consumed in Great Britain had risen from three thousand millions in 1920 to about fifteen thousand millions. Those were very happy signs from the point of view of smoke abatement and he thought they showed conclusively that on that subject the public was thinking correctly.

COUNTY COUNCILLOR FOUCHARD said that he was himself a coal worker and spoke as such. A scientist once made a statement that all the heating, lighting, and energy required would one day be provided without the miner having to go down into the earth for coal. Before that day arrived, however, there must be work for the miner, and to-day the introduction of machinery was gradually dispensing with the miner. The miner's lungs, he wished to remind the conference, were made more black than those of any individual living in a smoky city.

Mr. A. B. MUNRO (British Commercial Gas Association) claimed that the gas industry was making a definite contribution towards the ideals of the Society by offering to the public two such smokeless fuels as gas and coke. Speaking from personal experience, his home had used these fuels for upwards of ten years, and he found that gas works coke was in every way as suitable for domestic requirement as the fuel produced by low temperature methods.

It had to be borne in mind that the Government research departments had collaborated with certain gas companies in London with a view to the study of the commercial possibilities of low temperature carbonization processes, and it had been freely admitted

that after two years' work that the process could not be made a commercial proposition.

In referring to the evidence submitted by Mr. Besant as to the effect of smoke and soot on vegetation Mr. Munro suggested that as it was considered advisable to subsidize the supply of milk for children attending school it seemed to him a useless waste of public money. The first essential to good health was cleanliness, and as long as present conditions existed in town life careful feeding would not overcome the diseases existing through lack of sunshine. Why not subsidize the gas industry and make it imperative for everybody to use the smokeless fuels it provided?

Mr. DAVID FULTON (Institution of Gas Engineers) said that although he was connected with the gas industry it was not his intention to advocate the superior claim of gas over electricity, or of electricity over gas, or of one or other as against solid fuel. His purpose was to deplore the meetings of the Society becoming the vehicle by which propaganda, naked and unashamed, in favour of specific fuels, was disseminated. The initial error lay in the acceptance by the Council of Bailie Smith's propaganda, a paper in favour of his particular gospel, 'low temperature carbonization.' His remarks on gas use and gas price were incidental, but were a sufficient peg for Mr. Hood to expatiate on the marvellous benefits of electricity, and Mr. Munro on the great advantages of using coal gas. If the Society was to allow its meetings to become a battle ground for the competing claims of individual fuels its own propaganda "smoke abatement" would become obscured and damaged. That would be a misfortune and it was to be hoped that in future the Council of the Society would exercise greater care and not accept papers suspect of propaganda for the use of particular fuels.

Dr. A. J. SHINNIE (Westminster) said that he had listened with very great interest to Bailie Smith's fascinating address, but that the specimens of lungs which the Bailie had exhibited to the Committee did not fill him with the alarm which had been aroused. Bailie Smith had pointed out the beautiful healthiness of a shepherd's life and had drawn attention to the unhealthy sooty conditions of the coal-miner's, and apprehension had been expressed by a representative of a coal-mining community as to the liability to tuberculosis of the coal-miner by reason of the unhealthy condition of his lungs. It was a fact beyond dispute that coal-miners were extraordinarily immune to tuberculosis, in fact the position was so favourable that they were near that of the fisherman and the gardener. In Dr. Ogle's Life Tables of Dusty Occupations fishermen was 108, coal-miners 126; whereas the file-makers were 433 and the Cornish tin-miner 690. These were the pulmonary tuberculosis death rates, a thousand being taken as a mortality figure for males 25 to 65 years. It would be seen, therefore, that the coal-miner, as regards pulmonary tuberculosis, was in a very satisfactory position, and, if he remembered

rightly, it used to be taught that the effect of coal dust was definitely antagonistic to the development of tuberculosis in the human body.

THE DUKE OF MONTROSE said that the papers they had listened to, and the ocular demonstrations they had had, must have convinced everyone present of the damage done by smoke, not only to health, buildings, plants, but also to industry of all kinds. The dirtiness of the cities was so uneconomic—the matter could not be allowed to drift. It was all very well to talk about smoke, but the evil would never be got rid of until they could put a smokeless fuel on the market as an alternative to the present dirty coal. Gas and electricity had an immense field before them, but he did not think they would, or could, wholly replace the open domestic fire. It was the domestic fire that did most of the harm, and it was there they wanted the smokeless fuel.

He had commanded a Volunteer Corps in Glasgow for 23 years, and it appalled him when he thought of the enormous percentage of recruits they had to reject because of physical development. Their standard was low, miserably low—just over a C3 population. The hearts of the boys and their spirits were all right. It was their wretched bodies that let them down. He blamed the polluted atmosphere for the poor health of the young people of the city.

The atmosphere was also a handicap to a city that was seeking new industries. In the past they were dependent in Glasgow upon heavy industries. They had now serious unemployment and had to look for new industries. When they came to look for new industries they thought of the manufacture of such commodities as food products, textiles, paper, and chemicals; and such industries were going to give a wide berth to that or any other city which had a polluted atmosphere.

The President in his opening address had asked if there was no Knox, or Burns, in Scotland to-day to voice the people's cause. He was afraid there was not Knox or Burns but there was another voice that could do so and that was that of the Scottish National Development Council. This was an important body, composed of their leading industrialists, and at that moment they were by Special Committee investigating the various processes for the production of smokeless fuel from coal. He did not know what the results of that committee's researches would be, but he hoped that before long some means would be provided for purifying the air of Glasgow, for he considered the questions of smoke abatement and smokeless fuel to be like twin sisters—they should always enter the ball-room hand in hand.

COUNCILLOR ALEX MUNRO (Glasgow) gave reasons why the smokeless fuel plant producing "Kincole" in Glasgow was stopped. The plant, he stated, had been running at a continuous loss, and figures were quoted showing the losses to the Corporation Gas Department.

ALDERMAN H. WADDINGTON (Halifax) said he thought Bailie Smith had combined gas, electricity, and smokeless fuels very well in his paper. They had no power to say what the people must burn. Municipal gas authorities were doing all they could to make a smokeless fuel for the people at a low cost. Halifax bought the best quality coal and produced the best quality coke, which was sold at 25/- per ton. Although chairman of the Gas Committee he had to admit that coke did not ignite very easily, nor would it burn freely. The average man had to live on £2 a week, and he must have something as good as coal, able to satisfy as well as coal did.

BAILIE W. BROWNHILL SMITH, replying to the discussion, said with reference to Mr. Hood's remarks, that while speaking about the gas industry he had said nothing against electricity. He had been chairman of their electricity committee when they had planned the great generating station at Dalmarnock, had been a member of the Departmental Committee that advised the Government on the development of electricity in Britain, and had assisted in getting the first electricity Bill through Parliament. But electricity did not *generate* power; it *transmitted* it. The power was generated in the steam engine, and for firing the boilers gas would be better than raw coal if it were cheap enough, because then there would be no issue of smoke, grit, or sulphur fumes from the boiler chimney.

Mr. A. B. Munro of the B.C.G.A., had said that gas works coke was as suitable as low temperature fuel. If so, why was there so much difficulty in selling it at anything like the price got for any low temperature fuel? Mr. Munro had not answered his question—why did gas undertakings carbonize coal at 1400° when everything volatile was out of it at about 700°, and any increase over that temperature spoilt the coke and the oil? Neither did Mr. Fulton answer it. Councillor Alex Munro said that their low temperature plant was run at a loss. The reason that the balance sheet did not show a surplus was because the gas manager refused to use the gas properly, which on the small scale it was made cost 2.5d. per therm to make, giving as a reason that if these two gases were mixed they would separate out in the pipes! Had the low temperature gas been sold at the same price as the high temperature there would have been a surplus on the low temperature plant of about £14,000 a year.

Saturday, September 29th. Conference, 3rd Session.

Chairman:

COUNTY COUNCILLOR H. ALSTON HEWAT.

THE CHAIRMAN, in opening the session said he wondered what was Dr. Jervis's real meaning of the word "slum." To him it meant everything that was detestable in housing conditions.

He hoped they would hear from Dr. Jervis a great deal of the housing and slum conditions in Leeds and in Glasgow. There was a density of population up to 180 per acre in Glasgow, while in the modern housing districts there was a density of six houses, or twenty-five persons, to the acre.

So long as they lived near coalfields so long would they need to use coal. But they need not use it in the raw state. He could not visualize local authorities compelling the use of gas and electricity, but he could visualize local authorities urging coal to be burnt in proper conditions. And even if they had only one coal fire for every house it would be a big improvement. It should be the duty of every authority to see that there was a sufficient supply of smokeless fuels to go round to all the houses.

Mr. Hewat then called upon Dr. Jervis to present his paper.

SLUM CLEARANCE AND THE SMOKE PROBLEM.

By Dr. J. JOHNSTONE JERVIS.

Medical Officer of Health to the Leeds County Borough and
Honorary Secretary of the West Riding of Yorkshire
Regional Smoke Abatement Committee.

The slum problem has many aspects, but there is one which has perhaps not received the attention it might, and that is the influence of the slum on atmospheric pollution.

I do not know who was responsible for coining the word "slum," but whoever he was, I cannot congratulate him on his achievement. He surely could not have realized the legacy of pain and tribulation he was leaving behind, especially for Medical Officers of Health, else he would have hesitated before producing such a monstrosity. In any case, having produced the term, he might have left a clue to its exact meaning.

As it is no two persons—and stranger still, no two dictionaries—agree as to its definition. Nor am I going to attempt to define it, but for the purposes of this paper I shall

assume that a common feature of all slums is overcrowding of the houses on the site. "Narrowness or bad arrangement of the streets and bad arrangement of the dwelling houses" are specifically mentioned in Part I of the Housing Act, 1930, as reasons for declaring an area to be an unhealthy area. Furthermore, free access of light and air is regarded as an essential of a healthy dwelling. No mention is made anywhere of the quality of the air, but by inference one may assume that where there is congestion on the site, the movement of air is impeded, and consequently the air in and around the buildings must become stagnant and impure.

There are many kinds of impurities in slum air—some injurious and others harmless—and it is presumably because of the presence of the former that there is so much respiratory disease among slum populations. It will no doubt be objected that most of the diseases of the respiratory tract are infectious in character, and that infection depends on contact rather than on the state of the atmosphere. I should be the last to minimize the importance of personal contact as a factor in the spread of disease, and where there is overcrowding, both of buildings and persons, the opportunities for contact are undeniably great; nevertheless the air is the medium through which the infecting germs pass from one person to another, and where that is already heavily charged with impurities, their passage will obviously be facilitated rather than impeded.

Again, the influence of the sun's rays on the spread of respiratory infection is well known. Apart from the psychological effect of gloom which itself is a direct incentive to disease, the soot and grit in the atmosphere inactivates the ultra-violet light and renders it functionless as a prophylactic. One of the worst features of the slum is lack of light. To it, perhaps more than to any other circumstance, England owes its reputation for rickety children and chesty adults.

Soot is undoubtedly responsible for a great deal of this darkness, as one readily realizes if one views a congested working class district from an elevated situation at a time when all the domestic fires are in full blast. The overhanging cloud is so dense that the outline of the houses is almost completely obliterated. In foggy weather the obscurity is even more accentuated, and one can then appreciate the "draw" of the brightly illuminated place of public entertainment and refreshment, and sympathize with those who prefer it to the dismal interiors of the houses. I sometimes think the most expeditious and most successful way of solving the drink problem would be the abolition of the coal fire, with its attendant smoke, grime and misery. It is sometimes stated in defence of the coal fire that it is cheerful; there is, however, this other side to the picture, but to realize it one must live

in the slums. A writer in Chamber's Journal in 1871 deploring the pollution of the atmosphere by coal smoke makes the statement "that the want of fresh air formed bloodless, slender and distorted children, whilst the misery of house accommodation led to much of the drunkenness which prevailed among parents." Such a description might still be aptly applied to many of the working class districts of our towns and cities.

Health Conditions in Leeds.

As an estimate—albeit an imperfect one—of the influence of the slum on the public health, let me quote some of the death and sickness rates which were got out for certain areas in Leeds recently represented as unhealthy, and either already cleared or awaiting clearance.

Take the first; let it for convenience be called (A). The average general death rate in this area for a period of ten years (1924-1933) was 23.5, or 74.1 per cent higher than the city rate which for the same period was 13.5; the death rate from respiratory diseases for the same period was 4.90, or 131.1 per cent above that of the city (2.12), and the infant mortality rate, again for the same period, was 134, or 55.8 per cent in excess of that of the city (86).

It should be observed that the Infant Mortality Rate is probably one of the best and safest criteria of the healthiness of a community, be it large or small, and according to some authorities—Brend for example—is closely related to atmospheric pollution. When one reflects upon the beneficial influence of light on growth, whether it be of the plant or animal, it is not difficult to subscribe to such a theory. At the same time I should not go so far as to say that smoke alone was to blame for a high infant mortality rate. There are indisputably other contributory factors, but smoke is certainly not one of the least important.

Now take the second area, which we shall call (B). The average general death rate, again over a period of ten years (1923-32) was 20.3, or 51.5 per cent higher than the city rate (13.4); the respiratory diseases death rate 4.62; or 113.9 per cent above that of the city (2.16); and the infant mortality rate 116, or 33.3 per cent in excess of that of the city (87).

In a third area, which shall be known as (C), the average rates over a ten year period (1923-32) were: General death rate 21.4, or 59.7 per cent above the city rate (13.4); respiratory diseases death rate 5.03, or 132.9 per cent above the city rate (2.16); and the infant mortality rate 131, or 50.6 per cent above the city rate (87).

These three areas may be taken as examples; the figures for the remaining areas are very much the same, as may be seen from the table which accompanies this paper. There

are other mortality figures, such as those for phthisis and measles, both of outstanding significance from the point of view of social medicine, which I might mention, and which support those I have already given, but I particularly desire to confine myself to those statistics which have a probable, if not a demonstrable relationship to atmospheric pollution.

So far I have confined myself to mortality. What of sickness? I do not propose to give the statistics of sickness in detail, as they would only confuse without strengthening to any material extent the case I am essaying to make against the air of the slums. Suffice it to say, as may readily be assumed, that they bear out in a convincing manner the implications of the mortality figures. For every death there were at least twenty cases in which the issue was not fatal, but whose illness entailed not only suffering to the individual, but loss to the community. Take the two diseases I have already mentioned, phthisis and measles (I should like to have included respiratory diseases, but not possessing complete information as to the incidence of individual members of this group I am unfortunately unable to do so)—the attack rate in each of these areas over a period of ten years (1923-32) for phthisis exceeded that of the city by 130 per cent. In area A the excess over the city was no less than 221 per cent. The measles figure, as might be expected having regard to the general distribution of the disease and its greater infectivity does not show such a marked discrepancy, nevertheless in one of the three areas (C) it was as much as 62 per cent above the city average. It is unnecessary to spend further time on this aspect of the subject. The figures speak for themselves, and though, as I have already pointed out, they have only an indirect and limited application to the matter under discussion, they do show, I submit, that existence in the slums is rendered more precarious by bad aerial environment.

The Destruction of House Property.

In the course of my duties as Medical Officer of Health I have had to make a personal inspection of thousands of dwellings of the poorest type in areas where the congestion varied from 60 to 80 houses to the acre. Many of these were old and showed unmistakeable signs of senile decay, but there were others not so old—shall we say in advanced middle age—in which similar signs were clearly visible, due in my opinion to exposure over a prolonged period to the devastating effects of soot, tar and sulphuric acid. Stonework was worn and crumbling bricks honeycombed and spongy, metal-work waferlike or non-existent, and roof tiles or slates brittle and broken. If one sought a demonstration of the destruction and disfiguration wrought by smoke, here surely was one. These

ugly, blackened habitations formed a picture which told more eloquently than words could the story of man's folly and the price he has had to pay for his slavish allegiance to "Old King Coal."

Twelve years ago I exposed in the centre of Leeds selections of stones and metals commonly used in the construction of houses and public buildings. They were taken in at the beginning of this year. All the metals and most of the stones display to a greater or less extent the eroding influence of the atmosphere. The deterioration has depreciated the value of all the materials to an extent which I fancy might be capable of exact measurement by experts. Multiply the period of exposure of these stones and metals by seven and you approach what might be accepted as the average age of the houses in the areas I have mentioned. Assuming this were done and that the same stones and metals had been used in the construction of the houses now under condemnation, they would either long ago have had to be replaced or to-day would be in an advanced state of decay as bad or worse than anything in the areas.

In this connection, besides the fact that coal smoke was the important agent of destruction, there are two other important factors to be taken into consideration, namely, the type of grate used and the kind of coal consumed. I do not know if you are all familiar with the old type of Yorkshire range. It is a curious contraption, efficient in its way, but the ugliest, dirtiest and most uneconomical appliance ever invented. There is nothing scientific, much less attractive, about it, and all that can be said in its favour is that, if given plenty of fuel, it will emit heat sufficient to warm the room and to do the ordinary household cooking. As a smoke producer it would break the heart of any but a Yorkshire housewife, who, having been harnessed to it for so many years, knows only its virtues but is blind to its vices. Coal burnt in such a range loses more of its thermal value in smoke and soot than it gives off as heat.

As is well known, the poorer the quality of the coal, the less the thermal efficiency and the greater the amount of smoke produced. Furthermore, the less the thermal efficiency the greater the weight of fuel consumed to achieve the same result.

If there is one feature that transcends all others in these slum dwellings, it is the prodigal manner in which coal is used. Most of the houses are overheated, and in some the fire in the living room never goes out. It has been estimated that the amount of smoke produced from a ton of coal of the quality used in these slum areas is between 5% and 6% of the total weight, the latter and greater figure being probably

the more accurate, especially having regard to the type of grate employed.

From enquiries made in area (A), which is the largest of the three areas, roughly 1,200 houses, it has been ascertained that the average weight (Summer and Winter) of coal consumed per house per week is $1\frac{1}{2}$ cwt. This gives a total annual consumption over the whole area of 4,680 tons, and an output of smoke—reckoned at 6% of the total weight—of 280 tons. The extent of the area is 19.8 acres, and the average density of the houses 61 to the acre, which means that to each acre there are 14 tons, and to each house just over $4\frac{1}{2}$ cwts. of smoke produced in one year. These figures are striking enough, but they become even more arresting when one takes the whole of the areas to be dealt with in the slum clearance programme of the Leeds Corporation, amounting in all to 160, with a total estimated at 33,500 houses.

Assuming as before that the weekly consumption of coal per house is $1\frac{1}{2}$ cwt. the gross weight of coal consumed in a year will be 130,650 tons. The weight of smoke produced by the burning of this quantity of coal, calculated at 6% of the gross tonnage, will be 7,839 tons, distributed over a total area estimated at 450 acres, or roughly 17 tons per acre. When I speak of smoke I mean the carbon, tar and all the other volatile products of coal combustion.

On the border of Area (A) and between it and Area (B) is a smoke station with a standard deposit soot gauge. The average annual deposit of soot in this locality during the last five years, as indicated by the gauge, was 287 English tons per square mile. This is 27 per cent higher than the average of all the gauges (five in number) in the city, or what one might term the city average for the same period. Compared with the average of the gauge in Headingley, which is a residential district with a density of not more than 12 houses per acre and a much greater consumption of coal per house, it is 147% higher.

Daylight Comparisons.

When we turn to the question of the influence of smoke on daylight I am in the fortunate position of being able to compare one of the condemned areas with another which has been recently opened out as a housing estate for working class families on the southern boundary of the city.

It should be explained that the extent of the estate is 230 acres and the number of houses 2,728 with a density of 12 to the acre. The houses are a mixture of the parlour and non-parlour types of working class dwelling mostly occupied by families from congested areas.

Observations of the amount of daylight obtained by the

Potassium Iodide and Sulphuric Acid Test in the condemned area over a period of one year (1933) gave a daily average of 5.68 milligrams of iodine, while in the new estate observations over a similar period gave an average of 7.24 milligrams of iodine. There was therefore, 20 per cent more daylight on the new housing estate than on the condemned area.

Yet another striking example of the obstructive effect of smoke on light is afforded by the sunshine recorders in the city.

Whilst the sunshine recorder in the centre of the city, which is virtually on the fringe of a recently represented unhealthy area showed a total of 1,316 hours of sunshine during 1933, the second recorder, situated in the middle of a rapidly developing housing estate on the eastern boundary of the city registered no less than 1,714 hours of sunshine in the same period, or 30 per cent more than that recorded in the central area.

Making every allowance for the movement of air and the influence of wind, it is obvious that the slum area suffers very much more from smoke and light obstruction than does the less thickly populated residential area, or the city as a whole.

The economic aspect of the subject is interesting. I am not going to attempt to assess the loss to the owners of property and the inhabitants of the houses in those slum areas resulting from the depreciation in value of buildings, furniture, clothing, etc., due to the atmospheric pollution—that would be too formidable a task—but manifestly it must amount to thousands of pounds a year. What I do want to draw attention to is the enormous sum of money expended on coal by these poor people—many of them on the dole or in receipt of public assistance.

In the Area (A) in which I pursued my enquiries, I ascertained that the average price paid for household coal is 1/4 per cwt. This is considered a low price, and obviously is for a rather inferior grade of coal. Assuming that all the 33,500 houses burn this grade of coal at the rate I have already indicated of $1\frac{1}{2}$ cwt. per house per week, the gross amount consumed in one year would be 130,650 tons at a total cost of £174,200. The amount wasted in smoke estimated at 6% of the total weight of the coal consumed is 7,839 tons, which represents a value of £10,452, or sufficient to build and equip 30 modern working class dwellings consisting of living room, three bedrooms, scullery and bathroom. The interest alone on the money (at $3\frac{1}{2}$ per cent) would maintain 18 families rent and rate free in modern houses of the type I have mentioned (rented at 8/- a week) for a year. That is the price the slum dwellers are paying for the privilege of having a coal fire, to say nothing of the extra cost entailed by having

to meet doctors' bills and other expenses directly or indirectly due to the smoky atmosphere in which they live.

The Effects of Rehousing.

Now look at the other side of the picture. All these houses are going to be swept away and the people rehoused either in flats at 40 to 50 to the acre, depending on whether they are four or five storeys in height, or in houses at a density of 12 to the acre. Let us assume, as is very probable, that flats will be the form of rehousing selected for at least some of the cleared sites, and that the flats will be four storeys in height. In the first place only one-fifth of the gross area will be covered by buildings, the remaining four-fifths being devoted to streets, playgrounds, gardens and open spaces. Secondly, not all the displaced families can be rehoused in flats; out of the 33,500 to be dealt with, probably not more than one-fifth can be accommodated in this way because of the fact that certain of the sites only are suitable for flats. I may therefore be premised that the density on that portion of the 450 acres to be flatted (some 150 acres in all) will be reduced from 70 to 40, that is 30 less than on the uncleared areas, so that even if the amount of smoke produced per house remains the same, there would be a reduction in the output from 17 to 9 tons per acre. Inasmuch, however, as the cooking range to be installed in the flats is of the back-to-back type with grate in the living room and oven in the scullery, capable of burning coal or coke, and that the grates in the first and second bedrooms are also capable of burning coke, it is reasonable to suppose that there will be a reduction not only in the weight of fuel consumed, but also in the amount of smoke produced. It should furthermore be borne in mind that such smoke as is emitted will be discharged at a very much higher level than in the uncleared areas, and into a space larger and less obstructed by other buildings.

The remainder of the cleared sites, amounting in all to about 300 acres, unsuitable for flats, could either be laid out for houses at 12 to the acre or be utilized for some purpose other than dwelling houses. Suppose it were all used for houses and the consumption of coal in those houses remained, as before, at $1\frac{1}{2}$ cwt. per week, the amount of smoke per acre produced annually would be 2.8 tons, instead of 17 tons on the uncleared sites.

We have now accounted for 9,600 of the 33,500 houses, leaving a balance of 23,900 to be built on new sites in other parts of the city. For this, an area of 2,000 acres will be required, on which will be erected houses at 12 to the acre. Here again the smoke output may be reckoned at 2.8 tons per acre, so that the 7,839 tons of smoke which fell on the

450 acres of uncleared site at a density of 17 tons per acre per annum would now be disseminated over an area of 2,450 acres at a density of only 3.2 tons per acre. As a matter of fact it will be considerably less even than this, because in the houses, as in the flats, the cooking range will be of the back-to-back type designed to burn coke or coal, and grates in the main bedrooms will also be of a type suitable for burning smokeless fuel. It may further be assumed that many of the tenants will prefer to heat the bedrooms either by gas or electricity, both of which are to be laid on to the estates and available for heating purposes at favourable rates.

The Opportunity.

When one reflects that the 33,500 houses represent just under 25 per cent of the total houses in the city, one realizes how great is the opportunity presented of doing something really effective to clean up the atmosphere and abolish the cloud of smoke which for so long has hung over the city. Other places with programmes of slum clearance perhaps not so big as that of Leeds, but yet involving considerable areas have a similar opportunity. It is estimated that by the end of 1939 in England and Wales alone, upwards of 350,000 houses will have disappeared and been replaced by new ones. Are these houses to be of the old coal burning, smoke producing type, or are they to be smokeless? It is for the people to decide, and for us to help and encourage them to a right decision. This is our opportunity as well as theirs, and great is our responsibility if we miss it. It is at such a juncture as this that one wishes one had the powers of a dictator and could insist that every house built with the aid of public money should be so constructed as to be smokeless. But even without such powers, we are not entirely helpless. We can so plan and equip the new houses that smokeless sources of heat will be available for all who care to use them—indeed, I should go further, and by the cheapening of coke, gas and electricity, make it economically advantageous for the tenants to use them in preference to coal. On every large housing estate there should be a bureau at which tenants can receive advice as to the best and cheapest methods of using all these forms of heat. It would also be helpful if persons holding the position of Estate Manager, or engaged in the supervision of housing estates, possessed a practical knowledge of the principles of smokeless heating which they could pass on when requested for information on the subject.

Coke is undeniably the cheapest and most satisfactory substitute for coal, but it must be the right kind of coke, and it must be properly graded. It is useless to offer coke in large quantities to people whose storage room is limited. It

should be put up in bags of convenient size and weight, and there should be a depot on each estate of any size at which it can be bought and where the correct method of burning can be demonstrated. In the past, purveyors of coke have taken too much for granted. They have made no attempt to educate the public in the use of their commodity, and they certainly have done nothing to counter the competition of coal, so far as its sale and distribution to people of limited means is concerned.

For flats, some method of central heating might be devised, which would make the burning of raw coal unnecessary, and eliminate smoke altogether. The danger of such a proposal is that it might be made the excuse for excluding flues, and thus gravely interfere with ventilation. Personally I am not enamoured of the flueless house, and, though economic considerations may override my objections, I shall still hold to the opinion that a room without an adequate outlet for the discharge of foul air is hygienically unsound.

Still, it should not be beyond the skill of the architect and the ventilation engineer to devise a substitute for the domestic chimney which, whilst effective, would not add greatly to the cost of the building. Even so, central heating, though it might serve for the warming of bedrooms, would not be suitable or convenient for kitchen use. One open fire in a house is an absolute necessity for heating water, drying clothes, and especially for the burning of scraps and matter of a noxious or offensive character. This fire should, of course, burn coke, and if it can serve the dual purpose of heating and cooking, as is the case with the back-to-back range to be installed in the Leeds houses, so much the better.

As pointed out in a previous paragraph, there is no question of the elimination of the open fireplace in the bedroom of the ordinary dwelling house, but this would be so constructed as to burn coke or be fitted with gas fire or electric radiator in accordance with the means and wishes of tenant.

The slum and the smoky coal fire are relics of a bygone and a visionless age. We are getting rid of the former; let us have sufficient courage and foresight to have done with the latter as well.

DISCUSSION.

Mr. F. BIGGIN (Institution of Heating and Ventilating Engineers) said that Dr. Jervis had made no mention of communal hot water service for a housing estate, by means of which each house could have hot water at any time and *ad lib*, from a central source. This system had been adopted in several colliery villages and on housing estates in several large towns. He also defended the

VITAL STATISTICS OF UNHEALTHY AREAS REPRESENTED FROM 1923 TO 1934 WITH
COMPARATIVE FIGURES FOR A HEALTHY AREA AND THE CITY.

	1922-1931.				1923-1932.				1924-1933.			City
	West Street	Cavalier Street	Wood-house Street.	Meadow Lane	New-town	Isle Lane	York Road	Marl-borough Street	Marsh Lane	Crom-well Street	Burey Hill Healthy Area	
Population	694	381	276	977	864	894	2272	2975	4308	2116	1753	485,000
Number of houses	222	103	83	229	245	229	603	871	1214	622	475	135,066
Density of houses per Acre on site	65	78	44	65	77	63	76	65	61	68	42	3.54
Persons per acre	202	288	145	280	260	217	286	220	217	232	175	12.73
Persons per house	3.1	3.7	3.3	4.3	3.5	3.9	3.8	3.4	3.5	3.4	3.7	—
Rooms per house	2.2	2.4	2.8	2.5	2.4	2.4	2.3	—	2.3	2.5	3.0	—
Persons per Bedroom	2.44	2.70	1.85	2.82	2.57	2.73	2.84	—	2.65	2.28	1.85	—
Death Rate	23.6	21.8	13.0	23.6	18.2	21.4	20.3	21.8	23.5	19.6	9.2	13.5
Birth Rate	35.3	30.4	25.4	26.5	32.1	29.1	29.5	26.8	33.3	28.2	9.2	15.9
Infant Mortality Rate	176	147	86	158	141	131	116	112	134	156	74	86
Death Rates from :—												
Measles	0.14	1.05	—	0.20	1.16	0.67	0.57	0.20	0.51	0.43	0.11	0.10
Whooping Cough	0.86	0.79	0.36	0.82	0.69	0.56	0.48	0.37	0.63	0.47	—	0.12
Influenza	0.58	0.26	0.36	0.30	0.58	0.45	0.92	0.47	0.91	0.95	0.17	0.43
Phthisis	3.31	2.10	0.36	1.43	1.50	2.13	1.89	2.35	2.81	2.32	0.29	0.96
Other Tuberculous Diseases	0.29	0.79	1.09	0.20	0.46	0.56	0.62	0.44	0.49	0.43	0.11	0.21
Cancer	2.16	1.05	0.72	2.15	1.50	1.19	1.41	1.78	1.46	1.56	1.08	1.44
Heart Diseases	2.31	1.51	2.90	5.12	1.27	2.35	2.42	3.60	2.92	2.50	1.60	2.11
Respiratory Diseases	4.90	4.99	2.17	4.20	2.24	5.03	4.62	4.20	4.90	3.21	1.31	2.12
Diarrhoea	0.86	1.84	0.36	0.92	1.97	0.89	0.84	0.74	1.14	0.85	0.17	0.26
Nephritis and Bright's Disease	0.86	0.26	0.36	1.02	0.23	0.45	0.26	0.57	0.26	0.38	0.17	0.38
Accidents & Violence	1.01	0.52	0.36	0.32	0.93	1.01	0.40	0.64	0.95	0.24	0.46	0.42
Other Diseases	6.34	6.56	3.98	6.45	4.63	6.15	5.85	6.42	6.50	6.24	3.76	4.96

Yorkshire Range as being capable of being used economically and efficiently.

COUNCILLOR C. E. KEENE (Leicester) said that if progress was to be made in educating the poorer people of the population to value a clean atmosphere, they must begin with the children in the schools. He wished the Executive Committee would go into this question and see in what way it could be dealt with.

Miss G. KNOX (Glasgow Women Citizens' Association) said that if they wished to have smokeless cities they must provide smokeless fuels for their domestic hearths. This seemed to be the lesson the conference had brought home most strongly. Further, those fuels must be made easily available to the ordinary citizen. She used coke in her home supplied by the Glasgow Corporation, but had to telephone to the gas works each time she needed a supply.

She wished the Society would make some suggestion or recommendation as to how smokeless fuel in a city like Glasgow could be brought to the door of the ordinary housewife. She wished to thank Dr. Jervis for that part of his paper that recommended a plan for the sale and distribution of smokeless fuels to people of limited means and with little room for storage.

COUNCILLOR G. W. CRAWFORD (Heriot-Watt College, Edinburgh) commented on the title of Dr. Jervis's paper, and felt that "Slum" was not a good word to use. It was resented by many Dwellers who felt that it lowered their self-respect. He preferred to call them "Congested Areas." He ventured to suggest that the Society might go the whole hog and advocate the use of electricity for all domestic purposes, which was free from the residual products of combustion found in other smokeless fuels. Unseen gases were frequently more dangerous than visible smoke. "Smoke Abatement" was too narrow a term, and he suggested "Atmospheric Pollution."

COUNCILLOR T. KNIGHTS (Hackney), referring to the statements of lack of storage for smokeless fuels, said he was surprised that in a city the size of Glasgow it was possible to be so behind the times in catering for the wants of the persons with limited accommodation. In London it was possible for the poorest to obtain coke in 28 lb. bags.

ALDERMAN MAJOR H. C. JOEL (Stepney) said that in Stepney they had atmospheric pollution as great as in Glasgow. They were supplying electricity for all domestic purposes at a cost of $\frac{3}{4}$ d. per unit. The users had ceased to burn coal, and the step had increased the activity of the gas company, which was also increasing its sales. The municipalities could set an example for cleaning the atmosphere, and could also bring about better means for supplying electricity and gas.

COUNCILLOR W. ASBURY (Sheffield, Rotherham, and District Smoke Abatement Committee) said that he thought a reso-

lution should be passed by the conference supporting the subject of the paper read by Dr. Jervis. He had drafted a resolution which he would read.

This was as follows:—

“THAT this Conference views with grave concern the slow progress made towards the solution of the domestic smoke problem, and urges the Government, in any new housing legislation, to insist, as a condition of subsidy, that the heating arrangements in all houses to be erected under such legislation, shall be of such a design as will obviate atmospheric pollution.”

He formerly moved this resolution.

The resolution was seconded and was supported in brief by several speakers, and on being put to the meeting by the Chairman it was carried unanimously.

COUNCILLOR THOMAS SMITH (Felling-on-Tyne) said he wished to support the resolution. The people wanted to get what fire they could at as low a cost as possible. They were troubled with smoke and fumes from burning pit heaps in his district, and he wanted to know what could be done with regard to this.

COUNCILLOR ALEX MUNRO (Glasgow) asked if Dr. Jervis had any experience on the effect of the burning of coal as a cause of cancer. The price of electricity in Glasgow had been reduced, and so had the price of gas coke. There was, however, still the same problem. He did not think that gas and coke fires were as efficient as electric.

Mr. J. W. BEAUMONT (Halifax) said that the remarks of Dr. Jervis re daylight comparisons between slum areas and recently opened out housing areas on the city boundary were very interesting and were amply borne out by their experience in Halifax.

They obtained daylight records at two of their stations. One was situated in the centre of the town—Wade Street—in a congested area and at a low altitude, while the other—West View Park—was $1\frac{1}{2}$ miles away in an open situation at a much higher altitude. The average daily amount of daylight at the first of these stations was about 25 per cent less than that recorded at the other. A further remarkable feature was the fact that the difference between the two was twice as great during the winter months as compared with the summer months. Whilst other factors may have had a bearing upon this, the prime factor was indubitably the fact that during the winter months a greater amount of fuel of all kinds was burned and consequently more smoke discharged into the atmosphere, which in the case of a congested area especially, added considerably to the pollution of the atmosphere and obstruction of light.

The need for education of the public in the subject of smoke abatement was apparent to all, although it was rather surprising and

disappointing to find that that section of the community which might have been expected to have had some regard to the purity of our atmosphere were either apathetic to or ignorant on the matter. It was possibly a result of the health education given in our various municipal clinics that the poorer section of the community were apparently more appreciative of the value of a clean atmosphere.

ALDERMAN D. P. CHARLESWORTH (Wallasey) expressed his approval of the suggestion in Dr. Jervis's paper, particularly with regard to the installation in dwelling houses of fireplaces suitable for the combustion of smokeless fuels. He wondered if the problem of the existing house with a number of years of life still remaining had been considered, particularly those of which rents had been increased from about 3/6 per week to 11/- or 12/-, and whether in these cases it would be possible to compel the landlords to instal the new fireplaces.

Dr. J. JOHNSTONE JERVIS said in reply that it was not possible to instal central heating in the small houses on the new housing estates now being erected on the clearance areas, but that central heating would be suitable for blocks of flats and would probably be the form of heating adopted for these.

He said that the sulphur fumes produced by coke did not cause the same damage as when the sulphur was attached to soot and tar, as was the case in the burning of raw coal. He gave an instance of how a piece of silk and a piece of cotton had been exposed to the atmosphere in Leeds for a period of six months, and how the silk had been eaten into holes by the action of the sulphuric acid in the atmosphere and how the fibres of the cotton had deteriorated in a similar way. The fumes from the burning of coke were more rapidly diffused and did not appear to do the same damage. In speaking of coke Dr. Jervis explained that both in his paper and in his reply he included in the word "coke" both high and low temperature coke.

He had agreed that they must educate the rising generation, but it was of little use to educate the slum children when they had not the means at home of putting into practice the lessons they were taught in school. First of all they must give them better houses to live in and teach them how to use these houses to the best advantage.

Dr. Jervis said that it was essential that coke should be properly graded for domestic purposes and should be sold in quantities suitable to meet the needs of the poorest. A new low temperature fuel was, he understood, about to be placed on the market which would greatly enhance the available supplies, and as the price was to be less than that of good house coal the public would have the opportunity of combining economy with smoke abatement.

Electricity, for domestic heating purposes, was impracticable at the present time. It was too expensive. It was doubtful whether electricity could ever be supplied at a rate which would make its use practical for all purposes in small working-class houses. Poor people

could not afford more than two shilling a week for fuel, and if they spent more than that amount the balance must come off the food budget. In no circumstances should that happen. One open fire was necessary in every house to burn refuse and other household waste; after all the fire was the best cleanser they had.

The question of burning pit heaps had been considered by the West Riding of Yorkshire Regional Smoke Abatement Committee, but a solution to the problem was difficult to find. They were still trying to discover a practical method of abating the nuisance.

There was no evidence that cancer was due to smoke. Research into the association between soot and lung cancer had been going on for a long time in Leeds as well as in other teaching centres, but without any definite results.

He thoroughly agreed with the terms of the resolution: "If all houses built under subsidy could be made to burn smokeless fuel the atmosphere would be greatly improved."

In conclusion Dr. Jervis proposed a vote of thanks to the chairman of the meeting, County Councillor H. Alston Hewat, and this was carried with acclamation.

LIST OF PUBLICATIONS—*continued from front cover.*

Proceedings of the Sheffield Conference, 1933. Containing the Presidential address, resolutions adopted, papers by Councillor W. Asbury, on "The Five Years Clause and other Matters arising from the Public Health (Smoke Abatement) Act, 1926"; Mrs. Millicent Jast, on "How the Citizen Takes the Air—the Personal Significance of the Coal Smoke Problem"; Messrs. R. H. Clayton and Charles Gandy, on "The Combating of Domestic Smoke in Industrial Areas." 8vo. pp. 60. 1/-.

Proceedings of the Glasgow Conference, 1934. Containing the Presidential Address, papers by Dr. J. S. Owens, on "The Measurement of Atmospheric Pollution"; Mr. Oliver Cochran, on "The Effects of Smoke upon Visibility and Aviation"; Mr. W. D. Besant, on "The Effect of a Smoke-laden Atmosphere on Horticulture"; Bailie W. B. Smith, on "Nature is Beautiful, etc."; Dr. J. Johnstone Jervis, on "Slum Clearance and the Smoke Problem." Also resolutions on grit emission and housing, and discussions in full. 8vo. pp. 72. Price 1/-.

Separate Conference Papers:

"The Progress of the Electrical Grid." by Robert Blackmore, M.I.E.E. 3d.

"The Production and Use of the New Smokeless Fuel 'Dryco' in Liverpool," by Ralph E. Gibson, M.Inst.C.E., M.Inst.GasE. 3d.

"Atmospheric Pollution as Affecting Visibility and Visibility as Affecting Aviation," by Messrs. M. G. Bennett, M.Sc., and F. Entwistle, B.Sc., of the Meteorological Office. 3d.

"The Complete Gasification of Coal," by T. R. Wollaston, M.I.Mech.E. 3d.

"The Fuel of the Future." by Sir Francis Goodenough. 3d.

"Powdered Fuel and the Smoke Problem," by Dr. J. T. Dunn, D.Sc., F.I.C. 3d.

"How Electricity Can Help in Abating Smoke," by Julius Frith, M.Sc., M.I.E.E. 3d.

"Power from Sources other than Coal," by Prof. Miles Walker, M.A., D.Sc. 3d.

"Furnace and Tank Boiler Design," by W. H. Casmey. 3d.

"The Smoke Inspector and the Cost of Production," by H. G. Clinch, M.R.San.I., M.I.H. 3d.

Published by other Organizations:

"Smoke Abatement and Fuel Economy in Steam Boiler Practice." (Manchester and District Regional Smoke Abatement Committee). pp. 11. 1d., post 2d.

"The Open Fire." (Manchester Air Pollution Board). 1d., post 2d.

"The Black Smoke Tax." Report of an extensive investigation into the cost of smoke in Manchester. (Manchester Air Pollution Board). 1d., post 2d.

Latest Publications

A new work of reference indispensable to all concerned with smoke abatement.

A treatise on
THE LAW RELATING TO SMOKE AND NOXIOUS FUMES
by the late

*Randolph A. Glen, M.A., LL.B., Cantab,
Recorder of Penzance*

*Of the Middle Temple and Western Circuit
Standing Counsel to the National Smoke Abatement Society.*

Editor of "Glen's Public Health" (14th Edition), etc.

With a Foreword by Sir Lawrence Chubb.

Published by the Society.

Price 1/- Post Free.

An important review of the present position of solid smokeless fuels.

Report
of the

SYMPOSIUM ON SMOKELESS OPEN-GRATE FUELS.

Papers and Discussion at the conference arranged by the Society in London on June 8th, 1934. Papers by E. K. Regan, E. W. L. Nicol, Col. W. A. Bristow, H. Cerckel, Mrs. G. H. Miles, Dr. G. E. Foxwell, John Roberts, and Dr. E. W. Smith.

Price 1/- Post Free.

At Last!

THE SMOKELESS HOME.

A popular 12-page illustrated pamphlet, with cover in colours, describing the ways and means for making the home smokeless. To be sold in quantities for general distribution. Single copies gratis. £5 per 1,000.

National Smoke Abatement Society



SIXTH ANNUAL CONFERENCE

to be held at

GLASGOW

(in conjunction with the Scottish Branch)

September 27th, 28th, 29th, 1934

PROGRAMME

National Smoke Abatement Society



President : H. A. DES VOEUX, M.D.

Chairman and Hon. Treasurer : Ald. WILL MELLAND, M.A., J.P.

Hon. Advisory Secretary : Sir LAWRENCE CHUBB.

General Secretary and Editor :
ARNOLD MARSH, M.Sc., Tech., M.Inst.F.

Vice-Presidents :

H.R.H. THE PRINCESS LOUISE, DUCHESS OF ARGYLL.

THE RIGHT HON. THE EARL OF STAMFORD

THE RT. REV. THE LORD BISHOP OF LONDON, P.C.,
K.C.V.O., D.D.

THE RIGHT HON. LORD NEWTON, P.C.

THE VERY REV. THE DEAN OF CANTERBURY.

THE VERY REV. THE DEAN OF WELLS.

SIR THOMAS BARLOW, Bart., K.C.V.O., F.R.S.

SIR OLIVER LODGE, F.R.S., D.Sc.

SIR NAPIER SHAW, Sc.D., F.R.S.

SIR ERNEST SIMON.

PROFESSOR J. B. COHEN, Ph.D., D.Sc., LL.D., F.R.S.

PETER FYFE.

Alderman W. E. HINCKS, J.P.

DR. J. JOHNSTONE JERVIS, M.D., D.P.H.

Coun. W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.

Central Offices : 36, King Street, Manchester, 2.

London Offices : 71, Eccleston Square, Westminster, S.W.1.

Scottish Branch.

Hon. President :

THE RT. HON. W. J. THOMPSON, LL.D., Lord Provost of Edinburgh.

Vice-Presidents :

THE RT. HON. THE LORD PROVOST OF GLASGOW
(ALEX B. SWAN).

SIR HUGH SHAW STEWART, Bt., C.B.

SIR JOHN STIRLING-MAXWELL, Bt., K.T., D.L., LL.D.

SIR DANIEL M. STEVENSON, Bt., D.L., LL.D.

SIR HUGH REID, Bt., C.B.E., D.L., LL.D.

SIR HENRY S. KEITH, LL.D.

PETER FYFE.

ROBERT IRVINE, Ex-Provost, Coatbridge.

Acting President :

BAILIE W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.

Hon. Secretary and Treasurer : ALLAN STEVENSON.

Lecturer : THOS. M. ASHFORD, A.M.I.Mech.E.

Offices : CITY CHAMBERS, GLASGOW.

PROGRAMME



THURSDAY, September 27th—

8-0 p.m. Reception by the Lord Provost of Glasgow (Alexander B. Swan, Esq.) in the City Chambers. For particulars see "Conference Arrangements" and Reply Form.

FRIDAY, September 28th—

9-30 a.m. In the Council Hall, City Chambers.

ANNUAL GENERAL MEETING

Chairman : The President.

AGENDA.

1. Presidential Address.
2. To approve the Minutes of the last Annual General Meeting.
3. To Receive the Annual Report.
4. To Receive the Annual Statement of Accounts.
5. Election of President.
Vice-Presidents.
Hon. Treasurer.
Council.
Executive Committee.
6. Any further business.

10-30 a.m. CONFERENCE. FIRST SESSION.

Chairman : Dr. John R. Currie, M.A., M.D., D.P.H.,
(Professor of Public Health, University of Glasgow).

Paper by Dr. J. S. Owens, M.D., A.M.I.C.E.,
Superintendent of Observations for the Committee
for the Investigation of Atmospheric Pollution,
Department of Scientific and Industrial Research, on

"The Measurement of Atmospheric Pollution"

(Dr. Owens, at the conclusion of this paper, will give
a demonstration of a new instrument for the measure-
ment of smoke emission).

Discussion.

11-45 a.m. Paper by Mr. W. J. Grassie (Meteorological Officer,
Abbotsinch, Paisley) and Mr. Oliver Cochran, C.A.,
Secretary, Scottish Flying Club, Ltd.) on

"The Effects of Smoke upon Visibility and Aviation"

Discussion.

2-30 p.m. CONFERENCE, SECOND SESSION under the auspices of the Scottish Branch.

Chairman : Sir John Stirling-Maxwell, Bt., K.T., D.L., LL.D.

Paper and Demonstration by Mr. Wm. D. Besant, Director of Parks, Glasgow, on

“The Effect of a Smoke-Laden Atmosphere on
“Horticulture”

Discussion.

3-30 p.m. Address by Bailie W. Brownhill Smith, D.L., C.B.E., Acting President, Scottish Branch, entitled

“Nature is Beautiful and Rejoices in her Loveliness”

“Only Man is Vile.”

Discussion.

SATURDAY, September 29th—

9-30 a.m. CONFERENCE. THIRD SESSION.

Chairman : County Councillor H. Alston Hewat.

Paper by Dr. J. Johnstone Jervis, M.D., D.P.H., Medical Officer of Health for Leeds, Hon. Secretary, West Riding of Yorkshire Regional Smoke Abatement Committee, on

“Slum Clearance and Smoke Prevention.”

Discussion.

11-30 a.m. Motor to the Trossachs (By kind invitation of the Glasgow Corporation).

Time-table and Itinerary—

11-30 a.m. Depart from City Chambers by Motor Coaches.

1-30 p.m. Lunch at the Palace Hotel, Callander.

2-30 p.m. Depart for the Trossachs.

3-0 p.m. Embark for sail on Loch Katrine.

3-45 p.m. Arrive Stronachlachar. Afternoon Tea.

4-45 p.m. Return to the Trossachs by boat.

5-30 p.m. Depart for Glasgow, via Aberfoyle.

7-0—7-30 p.m. Arrive Glasgow.

Please Read Carefully.

Conference Arrangements



Hotel.

The Conference Headquarters will be the North British Station Hotel, George Square. Members and delegates in reserving their rooms should mention that they are attending the Conference in order to obtain the special terms which have been arranged.

These are :—

Bed and Breakfast, per day 14/-

Dinner Thursday to Dinner Saturday, inclusive (excluding luncheon on Saturday) £2 4 6

Dinner Thursday to breakfast Monday .. 25/6 additional.

Reception.

Those desiring to receive an invitation to the Lord Provost's Reception on the Thursday evening should indicate this on the accompanying Reply Form. An invitation will then be enclosed with the other papers to be sent out.

Motor Tour.

It is hoped that those attending will participate in the Motor Tour to the Trossachs on Saturday as guests of the Glasgow Corporation, by whose kindness the tour is being arranged. Indicate on the Reply Form whether you intend to be present.

Meeting Places.

The Annual General Meeting and all Conference sessions will be held in the Council Hall, City Chambers. This is in George Square, close to the North British Station Hotel. The Reception will also be held in the City Chambers.

Glasgow Guide.

Copies of a Guide to Glasgow, with maps, places of interest, and short tours, will be forwarded to delegates and members attending prior to the Conference.

Papers.

Copies of the papers to be presented, Annual Reports, Guide, and Reception invitation, will be forwarded a few days before the Conference to all from whom the Reply Form is received.

Date for Reply.

The Secretary will be obliged if those intending to be present will return the accompanying Reply Form as soon as possible, and in any case not later than September 22nd.

Resolutions.

Resolutions for submission to the Annual General Meeting or Conference may be sent in up to September 14th, and copies will be sent out with the papers and tickets.

Contributions to Discussions.

Delegates taking part in the discussions are requested to hand a copy of their remarks to the Secretary at the time, or to forward them to him as soon as possible afterwards, in order that they may be included in the proceedings of the Conference.

Proceedings of the Conference.

The **Proceedings** to be published in November, will contain the papers and discussions in full. A copy will be sent free of charge to each person attending the Conference and further copies will be obtainable at a rate of 1/- each or in quantities at 9/- per dozen.

Literature and Exhibits.

Copies of the Society's publications will be displayed and may be purchased during the Conference. A selection of exhibition material will also be displayed.

Further Information.

Any further information may be obtained upon request from the Secretary, National Smoke Abatement Society, 36, King Street, Manchester, 2, up to September 25th, and afterwards at the Conference Office, Smoke Abatement Conference, North British Station Hotel, Glasgow, or from the Hon. Secretary, Scottish Branch, City Chambers, Glasgow.

36 KING STREET,
MANCHESTER, 2.
BLACKfriars 0896.

ARNOLD MARSH,
General Secretary.

ANNUAL CONFERENCES.

1929	..	Buxton.
1930	..	Leicester.
1931	..	Liverpool.
1932	..	Newcastle-upon-Tyne.
1933	..	Sheffield.

CONFERENCE NOTES.

400 proofs +

400 copies -

November 11th 1936.

C 314

National

L 43-15-0.

Smoke Abatement Society

NATIONAL

SMOKE ABATEMENT SOCIETY

Chandos House, Buckingham Gate,

Westminster, S.W.1.



A 11

B 1 p9

B 44 p28

B 43 p35

B 61 p43

A 11 p54

B 1 p85

PROCEEDINGS

of the

B r i s t o l

Conference

1935

RETURN TO

NATIONAL

SMOKE ABATEMENT SOCIETY

Chandos House, Buckingham Gate,

Westminster, S.W.1.

Price

One Shilling

36 KING STREET

MANCHESTER 2

List of Publications

(All prices include postage. Reduced Prices for Quantities).

Smoke Abatement Handbook. A *vade-mecum* on all aspects of the smoke nuisance and its abatement. Indispensable to all who are concerned with the subject. 8vo. pp. 48. 6d., 5/- per dozen copies.

The Journal of the N.S.A.S. The Journal is not a record of proceedings but a magazine—the only one in the world—devoted to the problems of atmospheric pollution. Contains authoritative articles, notes on technical subjects, news of activities of every kind, and in general keeps the reader up-to-date in every aspect of the subject. Per annum, 2/6. Gratis to members.

The Law Relating to Smoke and Noxious Fumes by the late Randolph A. Glen, M.A., LL.B., Cantab, (Editor of "Glen's Public Health," etc.). With a foreword by Sir Lawrence Chubb. A comprehensive and practical survey of the legislative side of the problem, written by an authority. 8vo. pp. 24. 1/-.

Fumifugium; or the Smoake of London Dissipated, by John Evelyn. This rare and fascinating book, first published in 1661 by command of Charles II., has been republished by the Society with an introduction by Miss Rose Macaulay. In spite of its age this indictment of the smoke evil by the author of the famous Diaries remains true, witty, and penetrating. Illustrated with original wood engravings and a portrait of Evelyn. Paper covers, 6d. Cloth-bound, 1/6.

Smoke and Fumes Nuisances from Road Vehicles. The technical and scientific aspects by Dr. J. S. Owens, A.M.Inst.C.E., M.I.Mech.E., and the legal position by R. P. Mahaffy, M.A. 8vo. pp. 16. 3d.

Smoke and Health by Dr. J. S. Taylor, M.D., D.P.H., Assistant Medical Officer of Health, Manchester. 8vo. pp. 12. 2d.

How the Citizen Takes the Air. The Personal Significance of the Smoke Problem. A delightfully written paper by Mrs. Millicent Jast. 8vo. pp. 16. 2d.

Smoke and Aviation. Full Report of the 1935 Conference on this subject. Four papers in full and discussions. "Smoke and Visibility" by C. S. Durst, B.A., Assistant Superintendent,

Continued on back cover

NATIONAL
SMOKE ABATEMENT SOCIETY
Chandos House, Buckingham Gate,
Westminster, S.W.1

PROCEEDINGS

of the

Seventh Annual Conference

of the

NATIONAL SMOKE ABATEMENT SOCIETY

HELD AT

BRISTOL

September 20th and 21st

1935



CONTENTS :

Presidential Address, "Barbarism", by Dr. H. A. Des Vœux	3
Resolution on the Smoke Abatement Report of the Manchester City Council	8
"The Sources of Atmospheric Pollution" by Dr. R. Lessing	9
Discussion on Dr. Lessing's Paper	23
Smokeless equipment in Housing Schemes	
"Electrical Equipment" by Geo. S. Francis	28
"Gas Equipment" by G. L. Jennings	35
"Equipment for Solid Smokeless Fuels" by John W. Beaumont, M.R.S.I.	42
Discussion on Smokeless Equipment in Housing Schemes ...	47
"The Smoke Problem and the Country Side" by Dr. A. G. Ruston	54
Discussion on Dr. Ruston's Paper	61
"Grit and Dust Emission from a Sanitary Inspector's Point of View" by L. H. Dibblin	65
Discussion on Mr. Dibblin's Paper	72
Resolution on Exempted Processes under the Public Health (Smoke Abatement) Act, 1926	75
Vote of Thanks	76

Friday Morning, September 20th. Annual General Meeting.

PRESIDENTIAL ADDRESS.

by

H. A. DES VOEUX, M.D.

BARBARISM.

Difficult it is to see ourselves as others see us, not merely do I means this in reference to our personal appearance which we can fondly appreciate—or dislike—when we are vain enough to consult a mirror, but more particularly our character, our behaviour, our thoughts and intentions. We find that we are frequently misunderstood in our meanings when in conversation with friends and connections on matters which are controversial or even unequivocal. But when we come to consider groups of people and aggregates the views which we take are often quite at variance with theirs, and thence arise the terrible tragedies of quarrels and finally wars.

What is the character of the English? Why are they so often called and thought of as hypocrites? What do we think of Americans, and what do they think of us? Similarly with the French and Germans, and at the present moment the Italians. The latter, under their present regime, have become one of the leading nations of the world and feel, as we have often done, the intense urge to find openings in the vast unoccupied spaces for their overcrowded population almost as dense as ours, and with few of the natural advantages that we enjoy. Can we see their point of view, or are they correct in calling us hypocrites? Are the Abyssinians barbarians, and are the Italians civilized? Each sees the other in a different light, and who is to be the judge?

When we come to consider the question of Barbarism, what points are we to seek. The word itself signifies the language of illiterate people, which was mostly onomatopoeic.

If I remember correctly the first people to use the word were the Athenians, who called the Macedonians Barbarians. And why? The former were great in all scientific, literary, and musical art, and probably the finest architects that the world has ever known. The latter were wild uneducated people, always at war and entirely ignorant: but they produced the two greatest warriors of ancient times—Philip and his godlike son, Alexander the Great, probably the finest General of all time. And yet they were Barbarians. Philip did not appreciate this, but Alexander did, and one of his great ambitions was to introduce into his country the culture of Athens, the pursuit of which he originated but did not live to continue.

Similarly we find that the next conquering and educated nation of the world, the Romans, looked upon the rest of the known world

as Barbarians, amongst whom the Britons of this country were numbered. Did they come here for their good or for ours? Was it our ambition or was it greed? We know the view taken by the Romans, but what was that taken by the Britons? I cannot say, but certain it is that the conquerors left as a legacy much of what we know now as our civilization, a great part of which was destroyed by the Barbarian Saxons. I think that I am correct in saying that a large proportion of our language is of Roman origin, that the fundamental laws of our country are Roman, and that our most precious possession—Freedom—we learnt from them; freedom and the ideals of freedom. Individual freedom of thought and action, so long as they were not used to the detriment of others. That we have callously misused this freedom is not open to doubt, but through the instinct of an educated democracy, we are improving slowly but surely, and though the constructive ability and idealism of a great dictator may work wonders for a country, they can only exist for the span of one life and leave foundations, some good, some bad.

This freedom which we are now discussing has been terribly abused since the commencement of the great industrial age. The aggregation of manufacturies in suitable places—suitable on account of the proximity of coal and iron to our sea coast and its harbours—caused an intensification of population, attracting the poorer agricultural labourers to those centres which offered them higher wages and more continuous work, unavailable in more sparsely populated districts.

But individual freedom called forth no united action to avoid overcrowding, bad housing, or control over atmospheric pollution. Hence we have the stubborn and onerous problem of dealing with these matters at enormous expense and against the active opposition of interested parties. At long last this great wave of resistance is breaking on the shores of public conscience, and subsiding. We have for a hundred years or more been clustering like sardines in a tin under the smoke pall of our "enlightened" cities, and admiring our superiority over primitive man, who, I am told, often thinks of our boasting about our civilization as so much hot air. We who have had at our command all the wisdom of the poets and ability of scientists, should surely be able to refute the charge of Barbarism. But what would the denizen of another planet think of a race which callously allows the filth of smoke to be regarded as a natural element? "Barbarous" he would say, and apply his handkerchief to his nose and filter out the offensive and irritating emanations. Primitive man sitting in his cave in a cloud of wood smoke was not so foolish. He took an intelligent interest in smoke and had his theories about it. And so have his descendants to this day (the Golden Bough, ages 73, etc). Certain natives burn the stomach of an ox in the evening, believing that the smoke will gather clouds and bring rain in the morning. In Hindu Koosh the priestess stupefies herself by inhaling the smoke from a fire of the sacred cedar, over which she crouches with a cloth over her head until she goes into

convulsions due to the asphyxiating effect. When she recovers from this state her words are considered oracular and prophetic. In the Eiffel mountains at Lent a beech tree was fired by straw and brushwood, and a strawman burnt in it—a relic, no doubt, of some ancient ritual with a living victim. If the smoke blew upwards it was a sign that the harvest would be abundant. Another custom was for boys to burn bones and filth in order to produce foul smoke to drive away dragons which were poisoning wells. The Slavonic peasant still believes that witches exist in black hail clouds, and brings a pot of charcoal on which he throws holy oil, laurel leaves, and wormwood, crying "Curse, curse, Herodias, thy mother is a heathen dawnsed by God." The fumes arise, stupefy the witches, who crash to earth, and the fall is made as painful as possibly by laying out scythes and bill-hooks upturned, and chairs with the legs in the air, so that the witches may break their bones.

These people had some logic in their creation of smoke,—we have none. We do not believe that smoke will create rain, or that it will make us inspired prophets, and we know that agriculturists find smoke the reverse of beneficial to crops. We can claim that the miasma hovering over our cities brings devils and witches tumbling from the clouds—in the shape of disease and dirt, but the descent is more harmful to the inhabitants than the witches. Primitive man had therefore a social conscience, for his rites were intended to benefit all, while we are content, if the smoke does not come on to our faces from a downdraught, that it injures our neighbour and not ourselves. The history of the chimney is instructive in showing how gracefully the pleasures and arts of civilization can mask the barbaric foundation of our character.

The need of a hole in the roof was only appreciated when braziers were replaced by fireplaces, and it was as late as the 12th century when the roof-hole was replaced by a hollow flue from the fireplace, by the side of the wall. In the 13th and 14th centuries appeared the round vertical stone conduit, with a conical cap. The 15th century saw the grouping of chimneys as we now find them, and the commencement of ornamentation with Gothic pinnacles, heraldic ornaments, pilasters and entablatures. Diaper work or spiral decoration now became the exquisite Tudor chimney, with its various forms. But even as late as that the peasant was satisfied with his hole in the roof, later supplemented by a small barrel shaft built into his turf roof. Bishop Hall wrote in 1620:—

"God wot! a silly Cote
Whose thatched spars are furred with sluttish soot,
A whole inch thick, and hung like Blackamoor's brows,
Through smoke that down the headless barrel blew."

So the beer barrel evidently was not as effective as was expected.

Even to-day chimneys are constructed of wicker and thatch in some parts of Wales. During the 18th century chimney design fell into decay, owing to the invention of the ugly but effective chimney pot. A problem with architects has always been to find an effective outlet for the smoke, never have they considered it their duty to minimize the smoke nuisance. This was an unimportant omission while the smoke was as innocuous as that from wood or peat, but with the advent as early as 1306 of the coal fire, the importance of coal smoke began to be appreciated, and a Royal Proclamation was issued forbidding the use of coal in London. Six hundred years have passed, and yet we have not settled the problem! Indeed, the English are a slow people!

The history of the efforts by rulers to prohibit the use of coal is well known to you all, including the prohibition, while Parliament was sitting, in Elizabeth's reign. But the first recognition by the people themselves, of which I am aware, was when in 1648 the citizens of London petitioned that the importation of coal from Newcastle should be prohibited on account of the injury it caused. But they were too late, for Parliament, like the old witch, was already accustomed to the asphyxiating effect, and hoped that the smoke would produce an oracular state of mind. Even to-day the minds of our legislators seem to be blurred and apathetic to this subject. One great event which marks an era in our cause was the publication of John Evelyn's "Fumifugium" in 1661, with his remarkable statement "that this glorious and ancient City" (of London) "which from wood might be rendered brick (like another Rome) from brick made stone and marble; which commands the proud ocean of the Indies and reaches the furthest Antipodes should wrap her stately head in clouds of smoake and sulphure, so full of Stink and Darkness, I deplore with just indignation" and then refers to the illnesses already recognized as being caused thereby. Interesting it is to note that he refers not only to the Darkness but to the "Stink" which in all probability he associated with the Sulphur to which he draws attention. His sentence in which he attributes "the distempers" to the "Hellish and dismall cloud of Sea-Coale perpetually imminent over the head of the City" is a motto which ought to be printed in large type, framed, and hung on the wall behind the Mayor's Chair in every city: with the addition "Hell's hell, and when there study to improve."

We must remember that in Evelyn's day the industrial chimney was unknown, and that he was simply referring to the domestic chimney, and perhaps small fires from such places as laundries and bakehouses. It was not until 160 years later that Parliament began to take cognizance of the serious effects of smoke and appointed a committee to enquire into it and other 100 years has passed and still there are local authorities who believe that "Muck means Brass."

It is over 30 years since our Society commenced the preaching of clean air, and though much has been accomplished in that time, we have still a long way to go before our ideal is reached. Legislation

can do good, but the great good can only come from education, education which will teach every inhabitant of this country that smoke in the atmosphere, from any and every service, is a sign of wasted coal, and that it is not only destructive to our great buildings, our vegetation, and everything that we possess, but it is a signal that Barbarism is still in our nature and that with all our education and civilization we are unable to appreciate that smoke is not a product of nature, or a natural constituent of the atmosphere, but that it is created by man for his comfort and convenience, and that it is our want of recognition of what is true civilization which allows this fouling of our atmosphere without an attempt at its prevention or even reduction. It is only of quite recent years that manufacturers have attempted anything valuable towards the improvement of our great cities. They built their factories, plain, ugly, offensive, like prison buildings, and as soon as they were rich enough, fled from these hideous, dirt-producing erections, and built tenements for their work-people who were born and bred in these filthy surroundings, while they spent all their free time in beautiful places far away from the evils which they had created. Could none of them have seen the value of our cathedrals and other ancient buildings? Could none of them have learned the lesson that cleanliness was as important for their operatives as for themselves? Could none of them, when designing a factory, have taken a lesson from the nearest cathedral with its beautiful precincts and closes, where the Dean and the Canons and all attendant Clergy can live and enjoy their surroundings? Why must it be imperative for a rich manufacturer to live ten miles from his source of wealth, which ought to be not only his work but pleasure and pride.

A Barbaric mind surely at work! No altruism. A purely material outlook, selfish to a degree that hardly can be fathomed.

A slow change seems to be occurring, but it is slow and faltering, and he must be a persistent optimist who can to-day visualize the beautiful manufacturing city of the future, built and designed not only for the making of money but for its educative value on the young lives of the future; beauty to be seen in the streets and in the houses; beauty and cleanliness which will be steeped in the blood and bones of children; beauty in surroundings which can never be forgotten, and by which they will learn that dirt and ugliness are a sin against nature and art, and which will guide them to future health and happiness.

Not until that day dawns can we assert that we have thrown off Barbarism and become civilized.

RESOLUTION ON THE SMOKE ABATEMENT REPORT
ADOPTED BY THE MANCHESTER CITY COUNCIL.

After the presentation of the foregoing Presidential Address and the customary business of the Annual General Meeting, a resolution was proposed, on behalf of the Executive Committee, by *Mr. Charles Gandy*, and was seconded by *Mr. Alderman Melland*, Hon. Treasurer. After discussion, and the acceptance of a small amendment the Resolution, in the following terms, was carried with unanimity :

RESOLVED :

THAT this Annual General Meeting of the National Smoke Abatement Society congratulates the Manchester City Council upon its action in appointing, and in approving the report and recommendations of, a special sub-committee to consider the desirability and practicability of increasing the use of smokeless fuels (including gas and electricity), and urges all other local authorities to appoint committees of their own Councils with similar terms of reference.

The Annual General Meeting then closed and was followed by the first session of the Conference.

Friday, September 20th. Conference, 1st Session.

THE SOURCES OF ATMOSPHERIC POLLUTION.

By Dr. R. LESSING, Ph.D., F.I.C., M.I.Chem.E., F.Inst.F.

Chairman: Alderman J. E. JONES, J.P.

It is perhaps not without significance that the coal smoke abatement movement owes its organized existence to an artist. Sir William Richmond, the founder of the original society, opened the campaign against what he could perceive with his eye, the sooty emission from chimneys. The early activities of the Coal Smoke Abatement Society, which together with the Smoke Abatement League of Great Britain is now merged in the National Society, were mainly concerned with visible smoke and its observation by inspectors for statutory periods with a view to setting the existing law in motion against incorrigible offenders, and with obtaining new and more effective legislation for the abatement of the evil. The establishment of proof of the obnoxious effects of coal smoke suffered from the inherent difficulty of proving a truism.

The need for methodically collecting information of tangible pollution throughout the country and analysing the data obtained by scientifically sound methods, led to the formation in 1912 of the Atmospheric Pollution Committee. This Committee was conducted originally on a voluntary basis by a few enthusiasts under the chairmanship of Sir Napier Shaw and later was taken over by the Air Ministry and the Department of Scientific and Industrial Research. The Reports of this Committee, of which the 20th was published this year, form a valuable record of the incidence of a limited number of polluting substances mainly derived from the combustion of fuel, and their topographical and seasonal distribution over a large and representative number of localities throughout Great Britain. Within their closely limited scope the data collected in 20 years form probably the most complete and continuous record of atmospheric pollution in any country.

The observations, valuable as they are, were never intended to show more than the general effect of chimney emission on the purity of the atmosphere. The principal method of ascertainment, the collection of solids from the atmosphere by spontaneous settlement and washing out with rain water, was not intended to prove, except by inference, the deleterious effect of the polluting substances on buildings, metals, textile fabrics or on the human and animal body. In the light of future research it should be possible to extract more information from this statistical evidence than could be obtained from the individual observations as and when they were collected.

Whilst the methodical work done during the last 20 years was intended to ascertain the amount and composition of the smoky pollu-

tion in the atmosphere, no systematic investigation of the effect of smoke has been made. A great deal has been written on the general qualitative damage caused by atmospheric pollution and attempts have been made on many occasions to assess this damage in monetary value, a most difficult if not impossible task in view of the insidious nature and of the multiplicity of factors involved. Efforts to abate the smoke nuisance have been mainly directed to the employment of "smokeless" heating agents, gas, coke, semi-coke, anthracite and electricity. As far as the abolition of visible smoke is concerned any of these would of course provide a complete cure. Methods of combustion of fuel liable to produce smoke have not been investigated adequately for the specific purpose of smoke prevention, nor have the results of trustworthy researches been popularized to a sufficient degree. Attempts to educate stokers of boiler plants and firemen of industrial furnaces have been spasmodic, and much more could be done by the more general institution of classes by local authorities and trade associations, possibly in collaboration with technical schools and colleges.

Furnace equipment and operating methods, particularly of large scale boiler and other heating installations, have been developed and improved to a remarkable extent of recent years. Whilst the object has been primarily one of a more economical utilization of coal and saving of labour, success in these attempts has generally had the effect of reducing or eliminating smoke emission. Little or nothing has been done in improving the combustion conditions of domestic coal fires and cooking ranges in the vast majority of existing dwellings throughout the country beyond the fitting of more up-to-date fire-places and in the case of new houses, the fitting of a variety of "smoke-reducers" of somewhat doubtful value.

The time has come when stock should be taken of the conditions of chimney emissions as we find them to-day and the problem should be restated in the light of the fundamental sources of atmospheric pollution. When this is done it will be found that the pollution consists of more than mere smoke and that agencies causing widespread nuisance and injury comprise factors other than visible smoke. One may even go so far as to say that the chief direct damage by chimney emissions is not due to their carbonaceous content, but is due mainly to the acid constituents of the products of combustion.

This does not mean that the visible components of smoke consisting of carbon and tarry matter are not of vital importance, for apart from their action in tarnishing metals, soiling textile fabrics, buildings and the human body both externally and in its respiratory system, they deprive us of sunlight and thereby are injurious to physical health and, by creating a depressing environment, affect our mental well-being.

Moreover, the obstruction by smoke clouds of the highways of aerial traffic is a danger to aircraft and thus impedes the natural progress of this rapidly increasing mode of transport, a fact most

forcibly demonstrated by the recent discussion on the subject before this Society.

In yet another direction the problem to-day differs from that at the beginning of the century by reason of the concentration of factories and public utility undertakings into larger units and, apart from the steady increase in the number of gas fires and electric heaters, by the installation of central heating in the rapidly increasing number of blocks of flats and offices, hotels, hospitals and institutions.

COMPONENTS OF CHIMNEY EMISSIONS.

In order to appreciate these developments it will be useful to examine the sources of chimney emission in greater detail and it will be convenient to do this under the three main heads of smoke, acid gases and dust.

SMOKE.

In order to consider the production of smoke, the behaviour of various fuels during combustion must be studied. Combustion is by no means as simple a process as might appear from the final products of the combination of oxygen with carbon and hydrogen. If we consider the combustion of even the simplest hydrocarbon we find that the reaction of oxygen with carbon and hydrogen passes through a number of intermediate stages before the final products, carbon dioxide (CO_2) and water (H_2O) are formed. The intermediate products may differ according to the conditions of combustion, which may range from slow combustion to explosion depending upon the proportion of oxygen present, homogeneity of mixture, temperature and pressure. Many theories have been advanced, such as the preferential combustion of hydrogen, the formation of peroxides, and the formation of aldehydes according to the hydroxylation theory. Some of these theories are still under discussion, and if the combustion of the simplest type of hydrocarbon, such as methane, presents these theoretical difficulties, how much more complicated are the conditions of combustion of the complex hydrocarbons, such as the so-called illuminants in coal gas, or the constituents of ordinary motor spirit.

Provided a sufficient excess of oxygen is available during the combustion of hydrogen, or of combustible gases such as carbon monoxide and simple hydrocarbons, the combustion is relatively complete, and the products are entirely free from smoke. Coal gas and producer gas must therefore be regarded as prototypes of smokeless fuels.

Liquid fuels are in some respects similar to gaseous fuels. As they are richer in carbon and free from non-combustible constituents, they require a greater amount of oxygen. In order to allow this oxygen to act quickly enough, the mixture must either be burned under pressure or, as in the case of heavy fuel oils, the temperature of the flame must be kept well above the ignition point of the fuel so as to ensure rapid and complete combustion. If this is not the case, as

during the lighting-up period of an oil-fired furnace, smoke may be produced even though an adequate excess of oxygen is present.

If we come to consider the combustion of solid fuel it will be simplest to begin with coke. Coke is made by the thermal decomposition at temperatures above 900°C of coal, whereby the volatile constituents or decomposition products, gas, tar and water are removed, the last named containing the ammonia liberated. If an ideal coke could be produced, i.e., one free from ash and other impurities and from which every trace of volatile matter had been removed, the material would have the chemical composition of pure carbon. When burned in oxygen pure carbon dioxide would be produced or, if burned in air, the carbon dioxide would be diluted by nitrogen and the excess of oxygen. In practice such an ideal fuel cannot be commercially produced and coke therefore contains varying amounts of ash, sulphur and residual volatile matter. In order to effect combustion, that is to say, to allow the oxygen to combine with the carbon, it is necessary to raise the coke to its ignition point which ranges approximately from 500° to 600°C . When this temperature is reached on the surface of a lump of coke, combination of oxygen with the carbon begins and a small portion of the heat thus engendered raises succeeding layers to and above the ignition temperature so that combustion can proceed continuously. The ignition point depends on the physical structure of the coke itself and to a certain extent on the volatile combustible matter left in it after carbonization. Whilst this volatile matter aids the ignitibility of the coke, it is so small in amount and of such a character that under normal conditions it does not produce any smoke. For practical and particularly for domestic purposes it is important to bear in mind the difference between ignitibility and combustibility of a fuel. Coke is undoubtedly less readily ignitable than, say coal, but—and this is an important point in starting a fire—once the ignition point has been reached by means of paper, wood or a gas poker, its rate of combustion will normally be adequate for maintaining a continuous fire.

For practical purposes it may be taken that direct combination of oxygen with solid carbon takes place; hence the flame produced by a coke fire is more concentrated and shorter than that of a coal fire. Its heating effect, therefore, depends mainly on radiation from the solid, incandescent pieces of coke. Moreover, as combustion is rapidly brought to completion, the flame is colourless or bluish and does not present the yellow appearance of the flame from coal due to partially burnt or cracked tarry matter.

The bulk of the coke used for domestic purposes is derived from gasworks. During the recent depression in the iron and steel trade metallurgical coke made in coke ovens has found its way into the domestic market. This coke owing to its preparation in greater bulk, at somewhat higher temperature and from more compact coal charges, is denser than gas coke and somewhat less readily ignitable. On the

other hand, it is claimed for oven coke that being generally made from washed coals it contains less ash than gas coke. Both varieties comply with the most stringent demands for smokelessness.

Exactly thirty years ago the late Thomas Parker proposed the carbonization of coal at a lower temperature than is usual in gasworks and coke ovens, for the production of semi-coke to which he gave the name Coalite. This was intended to supply a solid domestic fuel more readily ignitable than coke, but free from that portion of the volatile matter in coal which would be liable to smoke formation. This is not the place to describe the vicissitudes of low temperature carbonization. If this process from the beginning had been developed on the basis of scientific and technical research and with due regard to its economic limitations, instead of being invested with mysterious and exaggerated potentialities and being made the plaything of unscrupulous financiers and a popular counter of the gambling public, this process might to-day occupy an important position in the industrial structure of the country. As it is, the production of semi-coke is only small as compared with the total fuel consumption of the country, but it is large enough to form a useful measure of its popularity with those who are in the habit of using this fuel. The economics of the process have been discussed *ad nauseam* on many occasions and from many angles, with pros and cons by the promoters of low temperature carbonizing companies and by opposing interests. In years to come it will probably be found that with the goodwill of all parties concerned the industry can be carried on with a normal moderate trading profit and will fulfil a useful purpose.

What matters from the point of view of to-day's discussion is that the fuel produced, provided it is made from low-ash coals and is of reasonable density and sufficient strength to resist breakage during transport and handling, should be welcomed as a smokeless domestic heating agent in addition to and not necessarily in substitution of, coke, anthracite, gas and electricity.

When dealing with the subject of coal from the point of view of smoke production the anthracite variety must be considered in a class apart. Anthracite occupies the highest place in the range of the coalification of plant materials. In researches on the formation of coal we are now accustomed to speak of its "rank," the "rank" rising from peat as the lowest member through brown coal and the various stages of bituminous coal to anthracite. It may be appropriate to recall that at this year's meeting of the British Association some time was devoted to a discussion on the "rank" in coal. The rise in rank of coal is brought about by the elimination of certain portions of volatile matter, with the result that in the highest member of the series, anthracite, only a minimum of volatile matter is left in the material. Anthracite may therefore be regarded as the product of a natural low temperature carbonization, carried on during geological periods at temperatures which are not likely to have exceeded 200°C. It is obvious that the

final product presents an entirely smokeless fuel and it is due to this and to the fact that, for reasons as yet not adequately explained, anthracite contains a very small percentage of ash, that this fuel occupies the premier position in regard to market price.

Coming now to the consideration of bituminous coal, the question arises how smoke is formed from it. Bituminous coal is fired in sizes ranging from lumps in the case of domestic fires down to small slack sizes on mechanical stokers. Combustion, whatever its intricate mechanism may be, proceeds mainly if not entirely on the surface of the particles or lumps. The heat liberated by the combination of the surface layers with oxygen progressively raises the temperature of adjacent layers, and eventually the interior of the whole mass is heated to a temperature approaching that of the outside. It thereby causes thermal decomposition to take place, very much on the lines of carbonization in a gas retort or coke oven in the absence of oxygen. While the outside of a piece of coal is burning, the interior is converted into coke, the volatile matter coming into contact with the combustion air only after it has left the solid particle in which it had been confined. As combustion does not take place instantaneously, and as the gases and vapours under normal draught conditions are quickly removed from within the fuel bed, they leave the bed in form of a flame the length of which varies with the coal employed. Being no longer in direct contact with the hot surfaces of the incandescent fuel bed, their temperature is lowered and a portion of the tarry vapours will therefore escape unburned or partially burned, whilst other portions are cracked to carbon which escapes as soot. In this manner the products of combustion are emitted from the chimney laden with smoke.

The progressive coke formation from coal on a chain grate stoker was studied by J. B. Maughan (Grumell, *J.Inst.Fuel* 1932, 5, 361) who found that "green" coal was completely coked after the fuel had travelled along one-half of a grate 10 feet long. What happened at different points of a travelling grate, will occur at different periods of time on a stationary grate. Whilst even during the coking period a certain amount of combustion takes place, this experiment shows clearly the sub-division of the burning of bituminous coal into carbonizing and combustion periods.

In properly designed industrial furnaces, such as an ordinary boiler furnace, the gases released from the fuel bed pass along an arch of refractory material which is maintained at high temperature. By contact with the hot firebrick and by radiation from it, the gases leaving the fuel bed unburned or incompletely burned, are kept at the requisite temperature, so that by allowing secondary air to be mixed with them, their combustion is completed. They will therefore escape without carrying any smoke with them.

In the domestic fireplace a furnace arch properly shaped for confining the gases is not provided. Considerable cooling therefore takes place above the fuel bed and unburnt tarry vapours remain in the

chimney gases without being subjected to secondary combustion. While sufficient air is present for supplying all the oxygen, both primary and secondary, required for total combustion, the cooling effect is usually too great to permit this. In fact the construction of the ordinary fireplace and particularly the old-fashioned one, is such that far too great an excess of air passes up the chimney, which in itself causes the gases to be unduly cooled. Whilst this large excess of air has a most wholesome ventilating effect, it is detrimental to the reduction or entire elimination of smoke. It is for this reason that domestic fires using bituminous coal are such prolific smoke producers and that the soot formed by them contains relatively high proportions of tarry matter. On the other hand, there is no reason why smoke should be emitted from steam boilers and other industrial furnaces if operated in a competent and workmanlike manner.

There is one form of industrial firing of bituminous coal which merits special consideration, the combustion of coal in pulverized form. By reducing coal in grinding mills to dust form so that the bulk of it, say 80%, will pass through a sieve of 200 mesh to the linear inch, and by blowing this powdered fuel suspended in the combustion air into furnaces, the mechanism of combustion is modified from that applied to coal in massive form. The particles are so small that a very intimate mixture of coal and oxygen is obtained, and the time required to burn each particle from its outer surface to its centre, is reduced to a minimum. The ratio of air to fuel can therefore be adjusted very closely and high combustion efficiencies are obtained which compare well with those of atomized fuel oil and approach even those of gaseous fuels. Since on account of the smallness of the particles the carbonizing and combustion phases practically overlap, and in view of the intimate mixture with the air, this system of firing is not likely to allow smoke, as distinct from coke and ash particles, to be emitted from the chimney.

ACID GASES.

Until a few years ago smoke was considered the principal contributor to "atmospheric pollution." It was known and realized that the sulphur contained in all fuels gave rise to the formation of acids which caused severe corrosion in everything with which they came in contact, in particular building materials, metals and textiles. The quantitative effect of these impurities has, however, not been realized and is perhaps even to-day not sufficiently appreciated.

In a paper submitted to the second World Power Conference 1930, I discussed these quantitative relations and compared the chimney emissions in respect of ash, dust and sulphur oxides as derived from ordinary coal and from coal which has been cleaned by the elimination of the natural coal dust and all removable impurities so that it contains only inherent ash and sulphur. The following table, calculated on a conservative basis, illustrates these conditions in respect of sulphur.

When applied to the case of a modern power station burning 2,000 tons of coal per day, figures are obtained which show the immense damage which would be caused, if no steps were taken, firstly for removing the bulk of the offending impurities from the coal

TABLE I.—SULPHUR DATA.

	A. Uncleaned coal.			B. Clean coal and dust mixed.	C. Clean coal.	
Sulphur in coal	3·0	2·0	1·0	0·77	0·75	Per cent
Gross calorific value	5,940	5,940	5,940	7,170	7,250	kcal/kg
RELATED TO 1 TON OF UNCLEANNED COAL.						
Coal required	1·000	1·000	1·000	0·784	0·770	Tons
Sulphur in coal	0·030	0·020	0·010	0·006	0·006	„
Sulphur dioxide in combustion cases	0·060	0·040	0·020	0·012	0·012	„
Sulphur trioxide equivalent CaCO_3 required to neutralise SO_2	0·075	0·050	0·025	0·015	0·014	„
River water (containing 20 parts of CaCO_3 per 100,000 parts) required to neutralise SO_2	0·094	0·062	0·031	0·019	0·018	„
CaSO_4 formed	469	312	156	94	90	„
Water required to dissolve CaSO_4	0·127	0·085	0·043	0·026	0·025	„
	64·0	42·5	21·3	12·8	12·3	„
RELATED TO 2,000 TONS OF UNCLEANNED COAL.						
Coal required	2,000	2,000	2,000	1,570	1,540	„
Sulphur in coal	60	40	20	12	11·5	„
Sulphur dioxide in combustion cases	120	80	40	24	23	„
Sulphur trioxide equivalent CaCO_3 required to neutralise SO_2	150	100	50	30	29	„
River water (containing 20 parts of CaCO_3 per 100,000 parts) required to neutralise SO_2	187	125	63	38	36	„
CaSO_4 formed	937,000	625,000	312,000	189,000	180,000	„
Water required to dissolve CaSO_4	254	170	86	52	50	„
	127,000	85,000	43,000	26,000	25,000	„

before burning, and secondly for extracting the residual portion from the flue gases before they are allowed to escape into the atmosphere. In such a case, practically the whole sulphur in the coal with the exception of a small portion retained by the furnace brick-work, and, according to the method of firing, varying portions of ash, dust or grit would be discharged from the chimneys.

As an example of sulphur emission the case of Greater London may be cited. In 1934 19,282,000 tons of coal and coke were brought into London and with minor exceptions, such as gas coke exported, were consumed in London. Of this total 6,282,000 tons came by rail, 43,000 tons by canal and 12,957,000 tons were sea-borne. The rail-borne coal may be regarded as mainly domestic and the water-borne as mainly industrial. Assuming the sulphur content of this coal to be 1 per cent., which must be regarded as a minimum, we find that a total of nearly 500,000 tons of sulphur, expressed as sulphuric acid, is discharged into the atmosphere from the 700 square miles of Greater London, industrial uses being responsible for about two-thirds and domestic consumption for one-third of the total. At the lower temperature of the domestic grate a little sulphur is probably retained by the ash which may call for a slight adjustment. An adjustment of this figure must also be made in respect of the sulphur removed in the purification of coal gas, amounting to about 55,000 tons per annum, and in respect of the sulphur contained in gas coke exported from London, which accounts for about 12,500 tons in terms of sulphuric acid. When the two large power stations at Battersea and Fulham, in which the sulphur is removed from the flue gases, are completed, a further reduction of the total by nearly 40,000 tons per annum in terms of sulphuric acid is to be expected.

It is gratifying to see that these industries in which positive sulphur removal is practised, are instrumental in reducing the total sulphur emission over London by about 20%. The balance of about 400,000 tons per annum of sulphuric acid still means the daily liberation of over 1,000 tons of the sulphuric acid equivalent of sulphur into the atmosphere of London, and it is safe to assume that with the true sulphur content in the coal actually burned this figure may have to be increased by nearly 50%.

It is interesting to compare this huge total with the sulphur oxides retained in the pollution gauges. A rough approximation of the SO_2 in the mean deposit in London shows an annual total of 25,000 tons, or only one-sixteenth of the original emission. It would be an interesting problem for the Atmospheric Pollution Committee to inquire into the final disposal of the balance unaccounted for. The major portion is probably carried away with the wind, but another appreciable portion is retained by way of corrosion and of disintegration of building materials.

A consideration of these quantitative data gives a plausible explanation of the destructive effect of chimney gases on stone, metals, textile fabrics and other materials which has manifested itself so widely, and in particular in such glaring instances as the decay of the masonry of the Houses of Parliament and other public buildings, to which attention has been directed so forcibly by the late Sir Frank Baines.

In dealing with the acid constituents in flue gases reference is not frequently made to the oxides of nitrogen. These are formed

in modern high temperature combustion processes to quite an appreciable extent and their contribution to atmospheric pollution must not be underestimated.

The presence of acids in chimney emission has only recently become an acute problem. After the claims of the aggrieved owner of land damaged by sulphur gases from the Barton Electricity Works of the Manchester Corporation were sustained by a judgment of the House of Lords in 1929, the Electricity Commissioners insisted that at the new London power stations to be erected at Battersea and Fulham, the necessary steps should be taken to eliminate practically all the sulphur oxides from the combustion gases of their boilers before discharge to the atmosphere.

It is a remarkable testimony to the power of public opinion that the outcry against the erection of two large power stations in the heart of the metropolis caused work to be undertaken which brought within the short span of five years a problem, then practically non-existent, from a state of almost complete ignorance on the subject-matter to its virtual solution.

The work done on independent lines by the London Power Company, by the engineers and technical advisers of the Metropolitan Borough of Fulham and by Imperial Chemical Industries Limited jointly with James Howden & Co. Ltd., must be regarded as technical achievements of a high order, considering that the standard set by the supervising authorities demands the extraction of 98% of the sulphur dioxide present in the flue gases in as low a concentration as 0.07% by volume, and that the volume to be treated in one station when fully equipped is 1,500,000 cubic feet per minute.

It should also be noted that in this field Great Britain has been leading, and in no other country have plants of similar dimensions yet been installed. Moreover, the process adopted at Fulham, although it employs wet washing, provides for the continuous recirculation of the scrubbing liquid without necessitating the discharge of a noxious effluent into the River Thames. The prevention of the escape of sulphur oxides into the atmosphere is therefore not effected at the expense of the purity of the river water. In order to make this possible and at the same time avoid the incrustation of the scrubbing plant with solid deposits, new ground had to be broken in elaborating the chemical reactions involved and in applying them on a very large scale.

DUST AND GRIT.

At one time so little attention was paid to the nuisance created by the emission of ash-dust from the chimneys of large power units that in a discussion before the Institution of Electrical Engineers in 1923 on a paper introducing powdered fuel into this country, I uttered a warning against the replacement of the vanishing smoke nuisance by a steadily growing dust menace. I discussed this matter in detail in the above-mentioned paper before the World Power Conference in

1930, and the following table shows the conditions of flue dust emission from boiler furnaces, for powdered fuel firing and mechanical stoking.

TABLE II.
EFFECT OF COAL CLEANING ON QUANTITY OF FLUE DUST EMISSION.
(Without flue dust catchers).

	A. Un- cleaned coal.	B. Clean coal and dust mixed.	C. Clean coal.	
POWDERED FUEL FIRING.				
Total ash	14·00	3·78	2·64	Per cent. of coal
Flue dust emitted	80	10	10	Per cent. of ash
Flue dust emitted	11·20	0·38	0·26	Per cent. of coal
Equivalent weight of coal ..	1·00	0·80	0·79	Tons
Flue dust emitted related to equivalents of 2,000 tons of coal A	224	6·1	4·1	„
MECHANICAL STOKING.				
Flue dust emitted	1·67	1·60	0·60	Per cent. of coal
Combustible in flue dust	70	73	80	Per cent. of flue dust
Equivalent weight of coal ..	1·00	0·78	0·77	Tons
Flue dust emitted related to equivalents of 2,000 tons of coal A	33·4	24·3	8·9	„

I then inquired into the behaviour of the various constituents of coal ash from the coal bunker to the chimney top and compared the potential dust emission from raw and clean coal. As in the case of sulphur, the totals were calculated for stations burning 2,000 tons of coal per day, and it will be noted that the improvements obtainable by coal cleaning are even more remarkable than in the case of sulphur.

A number of dust catchers have been introduced, employing either dry or wet operation. In one type of dry dust catchers cyclones are employed in which the dust is eliminated by centrifugal action; whilst these are quite efficient in removing the major portion of the coarse dust, they are usually not capable of catching the finest grades of dust. Another type employs electrostatic precipitation. This is of high efficiency although correspondingly expensive in installation and operating costs. The wet scrubbing system has the advantage, if properly designed and operated, that it can deal simultaneously with dust and sulphur oxides. In the case of Fulham, for instance, a 98% sulphur extraction efficiency involves a practically complete removal of all dust without any special provision in the plant.

A Committee appointed by the Electricity Commissioners to consider and report upon the measures which have been taken both in this

country and in others to obviate the emission of soot, ash, grit and gritty particles from the chimneys of electric power stations, made a careful inquiry into this problem and issued a report in 1932. A Committee of the British Standards Institution is now engaged in working out a standard specification for testing the concentration of flue dust in chimney gases and the efficiency of dust extraction plant.

The problem is therefore receiving attention, but what remains to be done is to spread the knowledge of the possibility of abating the nuisance and to take steps in applying this knowledge by making provisions for the installation of efficient cleaning plant a standard equipment of boilers and industrial furnaces generally.

It is to be hoped that the action of the Council of the Society in submitting to the Minister of Health the resolution in regard to dust and grit emission passed at the Glasgow Conference in 1934 and in calling attention to such nuisance arising from smaller plants other than generating stations and statutory undertakings, will have the desired effect of providing local authorities with expert technical advice.

The flue dust nuisance is by no means restricted to industrial furnaces proper. There is a rapidly increasing danger of a serious addition to atmospheric pollution by dust from the boilers installed for central heating and hot water supply in the rapidly increasing number of flats, offices, hotels, hospitals and institutions already referred to. In the individual dwelling house with its multiplicity of separate chimneys for each fireplace, reasonably low flue gas velocities are employed and consequently dust emission is restricted. In the larger buildings, each serving a small community of people, the heating services are centralized, and in consequence assume quite appreciable proportions. The flue gas velocities, therefore, become so high, particularly where forced draught is employed, that there is a risk of dust and grit being ejected, which owing to the usual situation in densely populated and high class residential districts, gives frequently rise to particularly objectionable nuisances.

REMEDIES.

The foregoing considerations may be summarized with a view to their practical significance in the following paragraphs :

(1) Smoke containing tarry matter is produced mainly from domestic coal fires. The obvious remedy is to substitute smokeless heating agents, anthracite, coke, semi-coke, gas, electricity, for raw coal in the open grate and kitchen range. This may be a counsel of perfection, seeing that the quantity of domestic coal consumed in this country is from 35,000,000 to 40,000,000 tons per annum, at which figure it has remained stationary for many years. This tonnage represents about one-quarter of the total consumption, and the capital expenditure required for the production of its equivalent of smokeless heating agencies is larger than the nation would willingly face in a short

period of time. Moreover, house coal commands the highest market price of all grades of coal and it is the obvious tendency of the coal producer to retain the market for this highly-priced portion of his output, to make up the deficiency caused by selling other grades below the average cost of production. Much as one would like to see it, the abolition of the use of raw coal for domestic purposes by the stroke of the pen is not within practical politics.

What should, however, be feasible is the improvement of the customary and highly inefficient method of managing the domestic fire. It should be possible to devise appliances and methods by which the eventual discharge of smoke into the chimney can be prevented without interfering with the brightness of the fire. It is satisfactory to note that the Coal Utilisation Council is contributing funds for an investigation of the subject by the Fuel Research Board.

(2) Smoke containing little or no tarry matter is emitted from industrial furnaces fired with coal or oil only in those cases where either the design or the operation is faulty. Improvement in this direction must be effected mainly by technical instruction of those directly and indirectly responsible.

(3) Acids, and in particular sulphur oxides, are formed in the combustion of all classes of fuel. An important reduction in the sulphur discharged is effected by coal cleaning, as shown in Table I. As the organic sulphur in coal cannot be removed in the cleaning process, the formation of some sulphur oxides from coal or coke cannot be avoided. Means are now available for economically eliminating the injurious compounds from flue gases, and if these are adopted wherever the size of installation permits, a very appreciable reduction in corrosive pollution will take place. As the two power stations at Battersea and Fulham will eventually account for a reduction of the sulphur emission over London by 10%, one may expect a very considerable improvement in respect of acid gases in a reasonably short time by multiplying the installation of similar plant.

(4) Dust and grit are liable to be emitted from all solid fuels in accordance with the physical laws governing the relation between size of particles and velocity of the gases carrying them. The remedies for this nuisance are practically the same as those for sulphur removal. By cleaning the coal prior to use, the ash of which flue dust mainly consists can be reduced as shown in Table II. With intensively washed coals, the flue dust evil practically disappears. I have shown in the paper previously referred to and in one on "Clean Coal in the Gas Industry" submitted to the Institution of Gas Engineers in 1931 that savings can be effected amounting to over 1/- per ton of boiler coal and over 2/- per ton of gas coal after allowing for the total cleaning expenditure.

The flue dust derived from the residual ash in coal and mostly also comprising some carbon particles, possibly in form of cenospheres, can be dealt with by dust catchers and scrubbers of varying efficiency.

SURVEY OF SOURCES OF ATMOSPHERIC POLLUTION.

Whatever expenditure is incurred in preventing or reducing the pollution of air from the various sources, must be offset against the damage caused by its insidious action. Sufficiently detailed and trustworthy statistical data for estimating it are not available, but it is certain that the damage suffered by the community amounts to a very large total and probably to not less than £1 per annum per head of the urban population. The time has come when this serious matter should receive more active consideration than has been given to it in the past. I suggest that the question of instituting a survey of the contributory causes of atmospheric pollution should be studied, with a view to preparing the ground and formulating methods by which such a survey could be carried out. The results obtained by the Atmospheric Pollution Committee during its 20 years' activities might form a starting point. Although its observations relate to only a relatively small phase of the problem, it should be possible to extract from them general indications of the sources of polluting matter discharged into the atmosphere beyond the portion actually collected.

In the first instance representative groups of the various types of chimney emission ranging from the small domestic fire to the largest power station boiler should be examined and the chemical composition and the physical condition of the gases should be ascertained.

An estimate of the distribution of coal in Great Britain in 1934 amongst the various classes of consumers is given in the following table.

TABLE III.—CONSUMPTION OF COAL IN GREAT BRITAIN IN 1934.

Consumer.	Quantity (Million Tons).	Percentage Proportion of Total.
1. Gas Works (excluding the coal equivalent of gas coke exported)	16·66	10·3
2. Electricity Generating Stations belonging to authorised undertakings and to railway and tramway authorities	11·17	6·9
3. Railway Companies (for locomotive use).....	12·17	7·5
4. Vessels engaged in the Coastwise Trade (bunkers)	1·26	0·8
5. Iron Works (used in Blast Furnaces)	10·40	6·5
6. Other Iron Works and Steel Works	6·81	4·2
7. Collieries (engine fuel)	11·68	7·2
8. General Manufactures and all other purposes (including Domestic use)	91·33	56·6
Total	161·48	100·0

The sources of chimney emission in a number of these groups are sufficiently uniform in themselves that fairly reliable conclusions can be drawn from the examination of relatively few examples. The greatest difficulty will be presented by Group 8, which is the largest and in which the great variety of general manufactures and all domestic fuels are lumped together. The planning of an inquiry into this group will therefore have to be done on the basis of a competent and very critical examination of the material already available.

It is hoped that the present paper might, after the elaboration of its general outlines in sufficient detail, form a skeleton on which a plan for a complete survey of atmospheric pollution could be based.

DISCUSSION.

Alderman J. E. Jones, the Chairman, in introducing Dr. Lessing prior to the presentation of the paper, said that he was glad to be able to welcome the conference to the ancient city of Bristol, one of the finest cities in the world. In declaring the meeting open for discussion after Dr. Lessing had spoken, Alderman Jones spoke briefly of the smoke nuisance as it concerned Bristol.

Mr. E. W. L. Nicol (London and Counties Coke Association), said that in his very excellent paper Dr. Lessing had laid much stress on the sulphur content of coke. He pointed out that in the carbonization of coal at gasworks the volatile sulphur was driven off and was collected as a bye-product. It followed, therefore, that the volatile sulphur content of coke was less than that of coal.

Councillor C. E. Keene (Leicester), referred to the point raised by Dr. Lessing in his paper regarding the installation of central heating for flats, offices, hotels, hospitals and institutions. In his opinion coal-fired central heating appliances were largely responsible for the sulphur nuisance. Was there not another method instead of coal for such heating? In his own factory he used forced gas.

Anthracite, he said, was very good, and he would like to see more of it in use, but its price was prohibitive.

Councillor F. Totterdill (Portishead), referred to the Power Station of the Bristol Corporation erected at Portishead, upon land purchased by the Corporation, and the effects it had on the village.

He thought it essential that the Corporation should enforce its bye-laws, and see that they were properly carried out, even with respect to its own undertakings.

Mr. L. H. Dibblin (Willesden), referred to the suggestion made by Dr. Lessing that all coals should be cleaned before using, and that this did not add to the cost. He wished to know if this could also be applied to domestic coals, and especially how could the cleaning be done without cost?

Alderman J. H. Waddington (Halifax), referred to the statement made by Dr. Lessing that "the abolition of the use of raw coal for domestic purposes by the stroke of the pen is not within practical politics."

In most of the northern towns and cities the municipalities provided the public services. Gas, water and electricity was supplied by most Local Authorities, and they had the power to turn these on for the use of all. Therefore, would it not be possible for all heating to be supplied by Local Authorities, so that the whole would be under proper control? Could Dr. Lessing say anything about this, and did he agree?

Mr. T. E. Birtwisle (Sanitary Inspectors' Association), congratulated Dr. Lessing on his excellent paper. Of all the papers he had heard at various conferences, none, he thought, had contained so much information in so small a compass. He would like to ask to what extent could sulphur be removed from coal during carbonization? He had been informed that it was not possible to reduce it by more than 1%.

Mr. R. H. Clayton, referring to Table 1, suggested that the analysis giving 3% of sulphur was a theoretical one in that the high percentage of ash and resulting low calorific figure given would render the material unsaleable.

He agreed that further work on the domestic grate burning raw coal was desirable. Domestic smoke from raw coal was more injurious than factory smoke in that it contained a very large percentage of tar, which is practically absent in factory smoke.

He said there was little hope of the present generation taking much interest in smoke abatement. He therefore suggested the girls of the future generation should be taught in the schools about the injurious influence of domestic smoke in home life, and by so doing get the co-operation necessary for rapid progress.

Dr. H. Osborne (Salford), said that Dr. Lessing had suggested they should use all available methods for smoke abatement. Following up a suggestion of Professor Boys regarding the suitability of a firebrick hearth for burning coke, the Salford Corporation Health Department had, 10 years ago, adopted a new firegrate for the use of high temperature coke, and had converted altogether 60 firegrates. In addition to having no smoke emitted from the chimneys, there had been a saving of 40% in the fuel bill. They had tried all kinds of smokeless fuel, but found the vertical coke to burn most successfully. They had since converted all the firegrates in a local Maternity Hospital to coke-burning grates.

The sulphur emitted from the burning of coke did not go into the room, but was poured into the air. Therefore they must get rid of the sulphur in coke, and further research on this question was essential.

Councillor Alex, Munro (Scottish Branch N.S.A.S.), thanked Dr. Lessing for his paper, and said it was one of the best ever presented at the Conferences. In Glasgow the smokeless fuel prepared by the Corporation (called "Dalcole") was being used in all their hospitals.

The price of coal in Glasgow was being increased, owing to the prosperity of the electrical industry. Councillor Munro said he was in favour of electricity in the home, as in coke there was found to be .8% of sulphur, and electricity was being supplied very cheaply in Glasgow—10 units for 3d. In England coke could be sold cheaper because coal could be procured at a less price. He suggested that the Government should support the coal industry, for what was the use of increasing the efficiency of generation in order to lower the price of electricity, when the price of coal was increasing and cancelling out the saving?

Alderman David Adams (Newcastle-upon-Tyne), congratulated Dr. Lessing on his most valuable paper, which he thought should be combined with the Manchester resolution adopted at the Annual General Meeting.

As a result of the Conference a great amount of practical work should be done by local authorities, particularly re new Housing schemes. He quoted the case of Newcastle, where coal could be obtained 15% cheaper than coke, but a coke fire might save 50% on present coal bills.

Dr. Lessing, in reply to the discussion, said that the aim of the Society should be to keep a sane and just balance when considering the various possibilities and methods of achieving its object, the avoidance or abatement of the pollution of the atmosphere. The Society should present a united front and rather than indicating preferences for individual smokeless fuels or methods of heating over others, should direct its energies towards that large balance of fuel supply which is used without regard to polluting effects. As an old member, having served on the Council for over 30 years, he would urge that the work should not be carried on in a short-sighted way by discussing petty differences between existing methods which were already contributing towards the solution of the problem, but it should aim at establishing the real facts of atmospheric pollution and assist in getting this work done.

The main object of his paper was to analyse the facts responsible for atmospheric pollution so that their relative importance could be appreciated.

Mr. Clayton, when referring to Table I, had assumed it to be based on theoretical considerations. He (Dr. Lessing) could assure him that the data were obtained in actual practice on a very large scale. Coal was still produced in this country which contained as much as 3% of sulphur, and consumers did not find it easy to secure large supplies of coal of a sulphur content low enough to satisfy their requirements. It was, however, only fair to say that the work

embodied in Table I had been carried out 5 years ago and that a very great deal of progress had been made during this time in the perfection of processes for the cleaning of coal and the cleaning of flue gases.

Whilst by efficient coal cleaning a considerable amount of sulphur-bearing impurities, such as pyrites were removed, the clean coal still contained that sulphur which was in organic combination with the coal substance. Although the sulphur percentage in clean coal might not be very greatly reduced from that in the raw coal, the total tonnage of sulphur burned was, of course, considerably diminished by the elimination of the useless sulphur-bearing impurities.

Somewhat similar considerations apply to the behaviour of sulphur during carbonization. A portion was taken out during that process with the tar, ammonia liquor and gas, but another portion became fixed to the carbon in the coke, with the result that coke, or for that matter, semi-coke still contained sulphur roughly in the same proportion as coal. During the burning of coke the sulphur was converted by combination with oxygen into sulphur dioxide gas which escaped into the atmosphere with the flue gases.

It might be said that every commercial fuel contained sulphur, and a small trace was even retained in coal gas, although gas purification reduced sulphur nowadays below the statutory limits which were formerly imposed on the gas supply of the Metropolis.

Mr. Dibblin had raised the question of cost of coal cleaning. Obviously cost was incurred in respect of the actual cleaning operations and of the loss of tonnage. The savings mentioned in the paper were the net effect of the advantages accruing from the use of clean coal after allowing for these costs. Hitherto only the nut and slack sizes had been submitted to dedusting and cleaning processes, and often the cleaning efficiency was not of a high order. There were, however, instances of lump coal for household purposes being cleaned by the gravity process resulting in a great reduction of the clinker produced from it.

Dr. Lessing expressed appreciation of the useful work done by the Manchester Smokeless Fuels Committee. The expenditure voted by the City Council for this work, to which Mr. Clayton had referred, was, however, totally inadequate for attempting a solution of the whole problem, and was very small when compared with the money spent on research and experimental work in the elaboration of the flue gas cleaning plants as installed at Battersea and Fulham.

He endorsed Alderman Waddington's plea for the supply of heat by public utility undertakings. Much progress had been made abroad in this direction by distribution of steam or hot water over relatively large districts, particularly in America and Switzerland. The centralization of generation would certainly facilitate the application of preventive measures.

The erection of high chimneys at power stations, whilst possibly affording some amelioration in the immediate neighbourhood, could not be regarded as a solution of the problem, as the polluting matter is merely diluted and shifted elsewhere but is not made innocuous.

In conclusion, Dr. Lessing expressed his conviction that progress would not be made by compulsory methods but was only possible as the result of research and the application of its teachings. The enthusiasts for smoke abatement should be certain of their ground when using economic arguments on the direct loss occasioned by the emission of black smoke. Detailed knowledge of the factors contributing to atmospheric pollution was still sorely needed, and in his submission the Society could employ its standing and resources most usefully by urging Government and local authorities to establish the survey of the sources of atmospheric pollution which he had suggested.

Friday, September 20th. Conference, 2nd Session.

SMOKELESS EQUIPMENT IN HOUSING SCHEMES.

Chairman: THE LORD MAYOR OF BRISTOL, Alderman H. J. MAGGS, J.P.

(1) ELECTRICAL EQUIPMENT.

By GEO. S. FRANCIS.

ABOLITION OF SMOKE.

If the total abolition of smoke is considered a desirable objective there are three ways by which it could be reached.

(a) By forbidding the burning of soft or bituminous coal (as in New York since 1905) except under technical conditions that ensure effective combustion.

(b) By taxing the use of smoke producing fuels heavily enough to render them uneconomic.

(c) By providing smokeless heat and power at a price that will tempt the public from older and cruder methods.

It is true that, under the anti-smoke regulations of 1905, all trains approaching New York are obliged to exchange their steam driven, smoke producing locomotives for electric locomotives before entering the city, and that the City of Vienna, in pursuance of their plans for smoke elimination, made it a condition in their lease with the Austrian Railways that the section of their lines operating within the city should be electrified, but there is little sign that any political or municipal body in this country contemplates tackling the smoke problem here by either of the direct methods indicated under (a) or (b). We are therefore forced back upon the third method (c) and along this line electricity is now playing an important and steadily increasing part.

It is of course true that technical development tending in this direction might be assisted and re-inforced by a steady stream of public education but it is fairly evident that such anti-smoke propaganda as has been conducted in the past has not succeeded in touching the imagination of the public deeply enough to arouse that fire of moral resentment which appears to be necessary for the removal of any major evil.

It is possible that further activity in this field might yet achieve some measure of success. The three primary essentials of physical existence—food, water, air—are each exposed to their own particular risks. In connection with food and water, public feeling has been sufficiently aroused from time to time to ensure the initiation of important steps in public hygiene. We spend millions of money and

employ expert brains to protect our food supply from adulteration and our water supply from contamination, but it is unfortunately still a fact that we spend little in effort, money or thought in protecting our atmosphere from pollution.

If means could be devised to convince people that while the depressing conditions of the 19th century might have been unavoidable *then*, they are not unavoidable *now*, if public imagination could be sufficiently aroused to see that the old conditions of dirt and filth are not only unnecessary but *rather disgraceful*, it is just possible that a passion for civic cleanliness and beauty might be aroused that would eagerly embrace the technical resources of to-day as a means of cleaning up the mess of the past and ensuring more comely conditions for the future. We have just had a glimpse of the possibilities that exist in this direction by the external wash and brush up that many public and commercial buildings received in celebration of the King's Jubilee this year. Some of the more important buildings, and even whole streets underwent a complete metamorphosis by the removal of smoke deposits from past years.

But while the above point of view might be considered a possibility, I am afraid we must face the fact that under ordinary circumstances no substitute for smoke producing fuel will ever become established on a large scale merely because it is smokeless. Smokeless alternatives to coal must commend themselves to users on other and more immediately practical grounds, such as greater convenience, labour-saving, money-saving, etc., and it is because electricity does offer these advantages, and to an increasing degree, that some knowledge of the part electricity is playing as an agent of smoke reduction is becoming a matter of public interest.

RECENT ELECTRICAL DEVELOPMENT.

The Electrical Industry is now the fifth largest industry in the country and has made remarkable technical advances during the past 12 years. In 1923 the average number of units of electrical energy generated from a ton of coal was 800, in 1933 it was 1,350, while in the best generating stations of to-day over 2,000 units can be generated for every ton of coal consumed.

In addition to the fact that fuel consumption steadily decreases in proportion to the energy output, elaborate steps are now taken to prevent emission of smoke, grit and flue gases from the chimneys of generating stations. Most power stations possess centrifugal or electrostatic grit-catchers to trap any grit that may be present in the flue gases, this provision having made marked advance since the introduction of pulverized fuel. The elimination of sulphurous gases from the products of combustion leaving the chimney stack has also received attention, in some cases by choosing coal with low sulphur content, in others by flue gas-washing plants. One such process is to wash the flue gases with a fine spray of warm water which combines with any

sulphur dioxide present to form sulphurous acid (H_2SO_3), which is precipitated and removed.

The salient fact that emerges from a study of modern generation methods is that the electrical industry is not only providing the cleanest form of energy known, but is also producing that energy in the cleanest possible manner.

But if the technical advances made in electrical generation and distribution are remarkable, not less interesting is the advance made in the mental attitude of the public to this development. During the early phase of its development (1890—1920) electricity was merely visualized as an alternative means of performing tasks that were already established and familiar. The provision of artificial light and heat, cooking of food, railway transport and the driving of industrial machinery were already in operation and carried on by some means or another, thus when electricity began to come into the picture it was merely accepted as a cleaner, more convenient and sometimes a more economical means of providing light, heat and power than by burning fuel on the spot.

But another phase has now commenced, in which we are beginning to perceive that electricity is not merely an alternative means of doing old and familiar things, it brings with it a new technique and a new outlook. We are slowly beginning to see that the real function of electricity is to enable us to do things that were never done before and to provide unique conditions of life and work which are unthinkable and impossible by non-electric means. Considered from this angle the effects electricity might produce towards reducing the smoke problems of the moment retire into relative insignificance before the conception that, by grasping the nature of electrical energy aright and by using it energetically and intelligently, we could produce a civilization in which the smoke, dirt and congestion of the past would fade completely out of the picture.

ELECTRICITY IN INDUSTRY.

At the moment of writing, four-fifths of our factories are using electricity for one purpose or another and more electric power is now being used to drive industrial machinery than all the steam, gas and oil power used at the beginning of this century added together. The effect of this development on smoke reduction can easily be imagined. Needless to say most of the factories using electricity are still the old factories built and placed according to the restricted and congested conditions appertaining to the age of coal and steam.

The age of coal and steam produced some of the most malignant forms of congestion and some of the most dangerous cases of maldistribution of population and wealth, on the one hand dirty, unhealthy, congested blocks of humanity, on the other a depopulated and devitalized countryside. The cause was simple. From the moment the steam engine was harnessed to industry, place and manner of

living became conditioned by it. In the steam age, problems of coal supply dominated everything. Railways were not originally invented to carry passengers, but to transport coal. Factories were compelled, for economic reasons, to cluster most thickly around the places to which coal could easily and cheaply be brought. The human and social rightness or wrongness of the situation were simply not considered, with the result that in such areas skies were blackened, rivers were polluted and people were herded in congested slums that beggar description.

In industrial areas the 19th century was a period of *chaos*, darkness and dirt, but the electrical technique of the 20th century is already beginning to show us what an industrial *order* might look like.

THE DECENTRALIZATION OF INDUSTRY.

Not only is electricity making the world's work easier, healthier and more pleasant, as well as more economic, but it can now be done in more healthy and pleasant surroundings. Electricity is liberating industry from the congested conditions of a fuel age and is providing the means for the development of a national economy from which the worst effects of a fuel-burning, smoke-producing age can be completely eliminated.

The newer factories and the new industries now developing in the south of England are large users of electricity under the influence of which a new type of industrial district is arising. Examples of this are to be seen at Welwyn Garden City and in many other districts in the Southern Counties in which industrial activity and healthy domestic conditions are happily wedded together. These cases, as well as others of their kind, are sufficiently decentralized to ensure pure air and a hygienic environment for workers and their families, while electricity with its high mobility make it possible to distribute heat, power and light over relatively wide areas without penalizing industry by high costs.

ELECTRICITY IN THE DOMESTIC SPHERE.

It is, I think, conceded that the problem of domestic smoke is not only the worst of its kind, but the most difficult to handle. Certain sentimental ideas about the open coal fire, the fact that fuel is still the cheapest method of providing continuous heat and the known reluctance of human beings to change their habits except under great inducement or pressure, all combine to make improvement in this field exceptionally difficult.

Nevertheless, while electricity can offer no promise of ensuring an immediate solution of the smoke problem in this sphere, electricity is exerting a distinctly beneficial influence. It has been known for some time that the provision of a complete electric service to new houses and flats saves construction costs, but this fact has often been obscured by doubts as to whether the running costs were within the tenants means. This question has been made the subject of expert inquiry by many

of the public and quasi-public bodies responsible for slum clearance and re-housing activities, with the result that positive and favourable evidence is now available and is being put into effect.

The re-housing schemes of many urban districts follow closely on the lines adopted by the L.C.C. The basic idea being that of blocks of dwellings composed of flats of various sizes, self-contained and equipped with modern appliances. With regard to the necessary services to such dwellings the first consideration is cooking, whether a coal heated oven is installed in the living room or no, some kind of cooker is essential in the kitchen, secondly a wash-boiler is required, thirdly hot water for bath and sink. If flues have to be provided for the cooker and the stove for water heating, the possibility of convenient planning is considerably restricted. It has been found that the adoption of full electric service at the outset not only saves construction costs, but also facilitates effective planning. Thus a full electric service, plus a coal fire in the living room, results in a more economical and convenient form of building, while the tenant is provided with heat for cooking, and heating water for washing day and the bath, with no more labour than is required to press a switch.

COST TO USER.

These modern conveniences would, however, be of little avail for the poorer sections of the community unless the price of electricity were low enough to bring the cost of using them within the reach of people with small incomes. The amount of money such people can afford to pay for light and heat has also been the subject of expert inquiry. It naturally varies somewhat from family to family, but for people whose incomes range from 40/- to 60/- per week it lies somewhere between 3/6 and 5/6 per week, out of which provision must be made for a coal fire in the living room for the winter months.

When electricity was used merely for lighting the costs of generation and distribution were met by charging 6d. or thereabouts a unit for the small amount of electricity that lighting consumes. But for this general service a different method of payment has been designed. Part of the costs are met by a standing charge, which in such cases is about 6d. per week, to this must be added the charge for the hire of the electrical apparatus installed, usually about 1/- per week, with a small unit charge of $\frac{3}{4}$ d. or $\frac{1}{2}$ d. for the current consumed.

One example of a case in which electricity is used for the heating and lighting requirements of re-housed tenants is to be seen in St. Pancras, where the L.C.C.—the St. Pancras Borough Council, the Commissioners of Crown Lands and the St. Pancras House Improvement Society have made an onslaught on the appalling conditions that once existed, and, during the past 4 years, have razed acres of slums to the ground, erecting in their place pleasing blocks of flats, each of which is equipped with every electrical amenity their tenants could need.

Except for one coal fire, all the lighting, cooking, water heating and certain smaller domestic operations such as ironing, etc., are performed by electricity. Each tenant has one coal fire in the living room which can be supplemented by electric heat for occasional use. On the basis of the above-mentioned charges the inclusive weekly costs for electricity supplied to the inhabitants of these blocks of dwellings range from 3/- to 4/6. On analysis, the average weekly cost to a flat consisting of kitchen, 3 rooms and bathroom is found to be as follows :—

	s.	d.
Hire of cooker, fire, electric iron and washboiler...	1	1
Standing Charge and Meter Rent.....		7
Current Consumed	2	1
Total	3	9

The tenants generally agree that electricity is reasonable in cost and they like it. If they prefer it they can use the living room fire for cooking—an oven is built over it—but very few do as electricity is found to be the cheapest and easiest way of cooking meals.

Progress in this direction is being carried on at a more rapid rate than is commonly realized. Numbers of other London Boroughs are developing on similar lines, giving a wide range of electrical facilities to their poorest tenants. In the provinces where development takes the form of housing estates, such well-known examples as the Sutton Trust and various municipal schemes such as at Hull and Bradford embody domestic electrification as a cardinal feature of their re-housing plans, while Preston (Lancs.) has already 1,025 such houses electrically equipped.

This movement is, however, not confined to towns and cities, it is spreading into villages and country districts and to-day there are few counties in the United Kingdom that cannot show some signs of rural electrification. As an example of this particular form of development mention might be made of the experience of groups of country cottages in the County of Dumfries, Scotland. The tenants were supplied with current on the basis of either a payment of 1/9 per week made up of standing charge, hire charge for cooker and hire purchase charge for the installation, or £1 per room per annum, plus hire rentals, and $\frac{3}{4}$ d. per unit consumed in each case. On this basis it is found that the average expenditure on electricity for lighting and cooking is just under 3/- per week, this cost naturally including the hire and standing charges. These results are in close accord with experience in many other rural areas. The villagers express general satisfaction with this service and state they are making a saving as compared with previous costs, while women, who may be working in the fields, find the convenience of the electric cooker a great boon when they return home.

This development is natural because electric equipment saves labour and keeps houses cleaner, it is desirable because it *rids the skies*

of smoke, it has been made possible by the fact that during the past 10 years the cost of electricity has been greatly reduced and special attention has been given to designing apparatus suitable for the poorest of homes.

ELECTRICAL EQUIPMENT OF SMALL HOUSES.

It has been admitted that electricity cannot as yet provide *all* the heat required in artisan households for the small amount of money available for this purpose. The practical question is therefore how much of the heat required for cooking and the heating of water for washing and other domestic purposes, can be provided electrically in addition to lighting. The greater the amount of electric heat used the smaller the amount of smoke emitted.

In small houses it is common practice to fit at least one coal grate, which is often part of a cooking unit, with a boiler for hot water supply. Such multi-purpose use makes the coal fire an economical means of obtaining much of the heat required during winter months, but its efficiency for any single purpose may be so low that it is more economical to use electricity than extra coal. A pot may be kept simmering on the fire without adding to cost, but if baking has to be done it may be more economical to use the electric oven than to make a large fire in the coal grate. The electric cooker is also more economical and convenient for cooking breakfasts, as well as for meals at short notice and odd intervals for workers whose meal times do not fit in with conventional arrangements. In summer the coal fire can be entirely dispensed with and the cooking done by electricity.

For water heating it is doubtful if fire back boilers are economically justified on account of the large consumption of coal needed to provide water hot enough for domestic purposes. As it is essential to provide a copper for boiling clothes, the electric wash boiler, which can easily be arranged to feed the bath, is the most economical and convenient arrangement. The electric cooker and wash-boiler are capable of supplying most of the heat for cooking, washing, bathing, etc., in small houses. Where these appliances are used the amount of money required for coal may fall as low as 1/6 to 2/- per week according to locality, size of family, etc., while the expenditure on electric light and heat, including hire of apparatus, will be on an average 2/6 to 4/- per week.

The possibility of developing this type of house is now fairly extensive. In every town in the United Kingdom of more than 100,000 population and in every one of the 28 London Boroughs electricity can be obtained for general domestic purposes, other than lighting, for $\frac{3}{4}$ d. per unit or less and this is also true of many smaller towns and of a steadily increasing number of rural districts.

ARCHITECTURE AND CIVIC PLANNING.

Architects are beginning to realize that without electricity the development of the "functional" school of design and architectural

form would be unthinkable. Electricity did not provide the inspiration, but it did help to realize the inspiration. Most large modern buildings now depend upon electricity to an extensive degree. In addition to their thousands of lights, electric power is needed to work lifts, drive ventilating fans and operate other internal machinery.

In some way or another these vast structures must be heated, therefore because of its great convenience, high efficiency and cleanliness, because the space usually required for furnaces, fuel storage, ash and refuse handling can be saved and labour economized, electricity is becoming more and more considered, not only as the best, but often the most economical method of heating. For these reasons electric heating is being incorporated more and more into commercial and public buildings. The architects of Bolton Civic Centre, Swansea Civic Centre, Manchester Central Reference Library, Kingston Municipal Offices, Chichester Council Offices, and a host of other buildings have cut adrift from old-fashioned heating methods have been able to plan their buildings and design their elevations unhampered by any consideration of the heating question. This means that architects are being delivered from the tyranny of the chimney and the flue, they can now plan their buildings with a flexibility hitherto impossible and with a greater eye for convenience and beauty. In employing electric heating the architect is not confined to any particular system, he can employ radiators or panels, unit heaters, or an air-conditioning installation according to the requirements of the building he is engaged in designing.

(2) GAS EQUIPMENT.

By GEORGE L. JENNINGS, M.I.H.V.E., A.M.I.GasE.

It is generally agreed that the chief and most stubborn offender in the matter of atmospheric pollution by smoke and soot is the domestic chimney. There is no need at this Conference to elaborate this point with examples and statistics; these are already well known. But I may point out that the best—perhaps the only way—of converting the domestic consumer to the cause we have at heart—the vital cause of smoke abatement—is to offer him—and this applies particularly to the working class consumer—something better in exchange for his old-fashioned smoke-producing fuel, and at a price within his means.

While, however, we always bear in mind the domestic pollution of the atmosphere, it is well to give some attention to the industrial uses of coal and to see what alleviation can be obtained there.

For instance, anyone who has visited the Pottery area must realize that although the great delinquent is the domestic chimney, yet at isolated areas the factory chimney can be a great offender. And as of necessity, Housing Schemes are chiefly required where the work lies, the amenities of life in these areas are affected by the industrial smoke.

B43

This is the reason why I bring the industrial smoke into this paper. It is no use building and equipping smokeless houses if contamination is coming from another quarter.

The purpose of this paper then is to show how modern gas appliances are being introduced into present-day homes, not only to provide the occupants with a cleanly, smoke-free fuel, but also to give them greater comfort for less work at an economic price; and to deal to a limited extent with the harm, preventable harm, done by the burning of raw coal in factories.

Comfort, cleanliness, health and efficiency in the home are closely bound up with the problem of the heat supply. Planned dwellings demand a planned heat service which will solve the problems of cooking, room warming, home laundry and water heating in the most efficient and economical way. This heat service, in turn, demands certain essential qualities. It must be flexible, easily controlled, clean and unfailingly reliable; it must also be economical to run so that it is within the reach of all classes of the community.

It is at this point that the interests of the enlightened town-planner and worker towards smoke abatement impinge on those of the gas industry. The very completeness of the service offered by domestic gas appliances to-day makes standardization of heat supply a simple and economic matter.

Modern gas appliances have been enormously improved within the last decade. How greatly their efficiency has been increased can be seen from the fact that tests show that the present-day gas cooker does the same work as the pre-war cooker for 30 per cent less consumption of gas; appliances for heating and water heating tell the same story. At the same time control has been so simplified that many appliances are to all intents and purposes automatic in action. Gas water heaters do their work with the merest supervision; gas cookers embody automatic oven control for simplified cooking; gas fires and gas lighting can now be made to answer a finger's pressure on a switch.

With these improvements has gone a considerable change for the better in the design of appliances. Enamel surfaces and stainless metal finishes make for easier cleaning and a smarter appearance.

Finally, running costs are low enough to make gas a really practical proposition in the working class home.

HOW GAS SERVES THE NEEDS OF THE WORKING CLASS HOUSEWIFE.

1. COOKING.

Every home must have provision for cooking of a capacity equal to the reasonable needs of the family and at a cost within their means.

The advantages and cleanliness of gas for cooking have been so widely recognized by housing authorities that gas cookers have been, and are being, installed as part of the standard equipment in the majority of dwellings erected under post-war schemes. The type, too,

of cooker used has been enormously improved since the days of the old black cooker, serviceable though that appliance was. On modern housing estates the cookers provided are commonly finished in enamel for easy cleaning and in many instances have the addition of automatic oven control by means of a thermostatic device—an invention which greatly simplifies oven cooking. The very wide variations of heat that are so easily obtainable with the gas cooker make it possible for the housewife to plan a more varied and more healthful choice of food than was possible previously without extra work. In cities and towns, and in fact wherever gas is available, quite 90% of the population cook by gas to-day. As far as cooking appliances are concerned, not only has the gas industry solved the problem of preventing smoke, but the solution has practically everywhere been put into effect.

In the industrial world, practically every mess room of our factories is fitted with gas burning appliances, both for the cooking and boiling of vegetables, etc. Many of these mess rooms cook and cater for hundreds of people and the contamination of the atmosphere avoided by using gas amounts in the aggregate to a very large figure.

Again, if we bear in mind that practically all biscuit makers to-day used gas fired ovens and that Messrs. J. Lyons & Company, probably the largest caterers in the world, use no less than 800,000,000 c.ft. of gas per annum, the universal use of gas for cooking is brought home to us.

Besides the domestic and industrial pollution there is another very bad class of offender that possibly comes midway between the two and one which you would have expected to avoid this fault in their own interests. I refer to the hotels. A short time ago I visited one of our best known health resorts and I saw the Medical Officer of Health. He told me that he had taken proceedings against four offenders only and in each case they were the large hotels.

The very people who profit by the fact that visitors go to their town to enjoy a clean air are the ones who contaminate it.

In addressing the Hotel Proprietors of Bournemouth a short while ago, I laid particular stress on this aspect of the matter.

2. WATER HEATING.

In regard to the heating of water, which used to be a secondary function of the smoke-producing kitchen range, gas has made very substantial progress.

The gas industry has produced a number of efficient and inexpensive water heaters that will supply hot water *instantly* all over the house at whatever point it is required, bath, basin or kitchen sink. These water heaters are entirely automatic in action when once lighted up and, since the gas consumption is, generally speaking, kept commensurate to the actual hot water needs of the family, they are economical in their working. Gas water heaters are now being installed in a number of the new blocks of working class flats or

garden city dwellings erected in connection with slum-clearance schemes, and by providing a constant hot water service are greatly assisting the cause of cleanliness.

The gas water heater, in all its varieties, is not the sole solution to the domestic water heating problem. There are hundreds of thousands of homes where a fairly constant supply of hot water is required, in which the alternative of the gas-coke boiler will be preferred, because the householder cannot afford the rather higher cost of the greater convenience of gas. The popularity of the coke boiler is growing at an astounding pace, some 120,000 being installed yearly. Not only are these appliances economical in use of fuel, but they call for little attention, are very consistent in results and are non-smoke producing. In many better class homes a combination of coke and gas is used satisfactorily for water heating—the coke boiler doing the work in winter, the gas water heater taking over the job during the warmer weather, when the quantity of hot water is considerably less.

It is also well to bear in mind that in the summer time the cold water is higher in temperature than in the winter. That is to say the rise in summer is possibly 60°F to 120°F, while in the winter it is often from 35°F to 120°F.

The gas industry thus contributes to the cause of smoke prevention completely satisfactory methods of cooking and supplying hot water; the first already generally adopted, the second in rapid process of adoption.

3. ROOM WARMING.

Improved design and construction, great efficiency and the very emphatic approval of the medical profession are among the chief factors in accounting for the increased adoption of gas appliances as a healthy, cleanly and labour-saving means of obtaining warmth. The modern radiant gas fire is making great headway in every class of home. For the warming of halls and passages there are neat and efficient types of gas radiators. While the sentimental prejudice for the solid fuel fire can be—and is being—turned to serve the cause of smoke abatement by the installation of smokeless coke fires ignited easily by gas burners.

At one time there was a prejudice against gas fires on the ground of health. But this prejudice, if not wholly dead, is rapidly dying. It arose from knowledge of the defects of gas heating as seen, say, twenty-five years ago, and may, of course, still persist where installations have not been brought up to date.

But it is wholly a mistake now-a-days to associate the gas fire, properly fixed to a flue, with any unhygienic or uncomfortable methods of heating. The modern gas fire warms largely by radiation, the most comfortable and healthy method of heating. Moreover, it has valuable ventilating qualities which must not be overlooked.

A point of great importance in the design and construction of the

small dwelling is the provision of proper ventilation. The flueless house has been condemned on hygienic grounds by the medical profession, a condemnation endorsed by leading architects. In the flueless house it has been found that there is a very real problem to deal with of condensation on interior walls in certain weather conditions. The gas industry has always stressed the importance of chimney ventilation in houses of all sizes, and can claim with truth that the gas fire is of material help in this connection, for a gas fire fitted with a proper flue, when alight is a perfectly adequate means of ventilation by drawing the used air in the room up the flue, and the flue continues to act as a ventilator at times when the fire is unnecessary.

For all rooms used intermittently, such as bedrooms, the gas fire provides a ready means of healthy radiant warmth at a small cost. Its value in cases of illness should not be forgotten in this connection.

In the living room, where a fire is needed throughout the day, gas at present-day prices may be somewhat expensive for the working class family. The smokeless alternative then, as I have said, is gas-coke which is the cheapest fuel for continuous use. Coke fires, generally with the addition of a gas burner for convenient lighting, are being installed in the living rooms on a number of new housing estates.

4. HOME LAUNDRY.

Unless properly equipped communal arrangements for washing and drying clothes are available at a reasonable distance, the working class dwelling should have facilities for clothes washing at hand. The gas wash copper is a suitable means of meeting this need, while a gas iron may be provided for lessening the labour involved in ironing the home laundry.

5. LIGHTING.

In many new housing estates gas is being provided for lighting, and in some cases distance switches are provided—an ideal practice which should certainly be followed where practicable.

Many working class tenants have definitely stated that they prefer gas lighting. Not only is it cheap in running costs, but the burner gives out a small modicum of heat which is just sufficient to make the room comfortable on chilly spring or autumn evenings when those who have to count their pence carefully would hesitate to light a fire. Moreover, gas being cheap for lighting, the user can afford to employ enough light to save the eyes from strain when doing close sewing or reading.

Certainly no Public Authority can participate in house building and instal coal burning grates without grossly neglecting the recommendations of the Report of the Committee appointed to enquire into Smoke abatement.

SOME TYPICAL EXAMPLES.

At this point I may draw your attention to some typical examples

of the way in which those responsible for housing schemes, public or private, are enlisting the help of the gas industry.

1. TENEMENT PRINCIPLE.

Princess Alice House, North Kensington. In this new block of 80 flats, erected by the Kensington Housing Trust, gas has been installed for cooking and wash coppers, and for heating most of the bedrooms. The lighting, which is gas throughout, is mainly switch-controlled. The rents of these flats, which will accommodate about 450 people from condemned areas, are from 7s. 6d. to 14s. 0d. per week, inclusive of rates.

These flats also embody a caged-in playground for children, sixteen allotments and 35 pram sheds. Dust chutes are provided at the four corners of the building so that dustbins are unnecessary.

The Highlands, Crouch Hill. The number of flats in this block, built by the Metropolitan Borough of Islington, is 71, at rents (inclusive of rates) varying from 14s. 11d. to 22s. 5d. per week. Each flat has a separate scullery and bathroom, and most of them have a private balcony. The equipment of each flat includes a gas cooker, a wash copper and a multipoint instantaneous gas water heater which supplies the sink and bath. One or more gas fires are fixed in each flat. The gas is supplied on a coin-in-the-slot meter that takes both pennies and shillings.

Other "all-gas" or practically "all-gas" blocks of flats in London are to be found in Peckham (where Sassoon House is an outstanding example), Hackney, Bermondsey, Brixton and elsewhere.

2. THE SATELLITE TOWN PRINCIPLE.

Housing schemes of the garden city or satellite town type are also making an extensive use of gas.

Up to December, 1934, 37,000 gas fires, 21,000 cookers, and 21,000 wash boilers had been supplied to municipal housing estates in Manchester. Of these may be mentioned the Wythenshawe Municipal Housing Estate, on which 5,500 houses are either completed or in course of erection. The estate will eventually contain 26,000 dwellings. Enamelled gas cookers with automatic oven control, gas wash coppers and gas fires in one or more rooms are to be found in the vast majority of houses on this estate.

Birmingham has over 40,000 dwellings erected under municipal schemes since the war. Everyone of these is piped for gas. In Liverpool during the same period the local gas undertaking has been called upon to supply the following appliances to dwellings built by local authorities—about 40,000 gas cookers, 40,000 wash coppers and 70,000 gas fires. Some 18,000 lighting points have also been fixed in these dwellings.

THE QUESTION OF COST.

The real economy of gas for cooking, heating and water heating

and lighting will be appreciated from the following figures giving the average weekly consumptions of gas in typical housing estates.

On an estate in Hornsey, consisting of 111 4-room flats equipped with a gas cooker, a gas wash copper, two or three gas fires and a gas-fired thermal storage water heater, the average weekly consumption per flat is 538 cubic feet. This costs, at current "prepayment" meter rates, 2s. 4½d. per week.

Every house on an estate in the Brentford district is provided with a gas cooker, a gas wash copper, at least one gas fire and one gas lighting fitting. The average weekly consumption per house is 500 cubic feet, costing at local rates through prepayment meters, 2/4 per week.

A third instance comes from Southall where the dwellings on a new estate have gas laid on for lighting, for cooking and for a gas wash copper. The average weekly consumption is 480 cubic feet, costing 2/3 per week.

The foregoing facts and statistics give only a brief outline of the work of the gas industry in providing the poorer classes with labour-saving domestic equipment that combines economy with a better standard of home comfort.

EDUCATING THE HOUSEWIFE.

Almost as important as the work of reconstructing and equipping the working class dwelling in accordance with modern ideas of comfort and convenience is the task of educating the housewife in the use of labour-saving appliances and ensuring that there shall be no return to the old regime of dirt and drudgery.

The need for proper educative measures is fully recognised by the gas industry.

By cookery and other demonstrations, not only at gas showrooms, but at unemployment centres and domestic science classes for working class girls; by house-to-house visitations by skilled women demonstrators and advisers; the gas industry is educating both the present generation and the coming one in the use of modern appliances for easier housework, and proving to them that cleanliness, health and comfort go together and need not mean a perpetual round of housework and drudgery.

At the same time by example and precept the community is being brought nearer to the realization that the cleanliness of the air we breathe is as necessary for health as is the cleanliness of the homes in which we live.

We are also delighted to say that in the industrial world great strides are being made to reduce the amount of raw coal now burnt. For instance, half the entire output of gas at Sheffield is used for industrial purposes with the corresponding abolition of smoke. Birmingham also shows splendid progress in this direction and many

other places are moving forward to a greater use of a heating medium which does not involve contamination of the atmosphere—Gas.

I have visited and spoken on Smoke Abatement at a large number of our towns and cities, and especially to the architectural students at our Universities, but everywhere I have been I have pleasure in recording the support forthcoming from the Authorities; both the Heads of the Educational Establishments and the Medical Officers of Health, without exception, when the matter is put before them, give their most cordial co-operation.

I have in mind the Head of one of our large Schools, who addressing the scholars after I had spoken, told them that as a Nation by burning raw coal we were committing suicide.

Such support from the Principal ensures that consideration will be given to the matter, and if we can secure that, our success is assured.

(3) SOLID SMOKELESS FUELS.

By JOHN W. BEAUMONT, M.R.S.I.

Chief Sanitary Inspector, County Borough of Halifax.

1561
In any discussion it is an advantage if there is some common ground of agreement from which we can make a beginning. In the present case I think that I may confidently assume that we are all agreed that smokeless equipment in the new housing schemes is not only desirable but absolutely essential to the health and well-being of the community.

At present there is more activity in house building than has been known before, and local authorities are, generally speaking, only at the commencement of their great slum clearance drive. During the next few years therefore, house building should be carried out to an even greater extent to replace the houses in slum areas which must be demolished. With such a golden opportunity before us we should be failing in our duty to the present generation and posterity if we did not do all that is humanly possible to ensure that these new houses contribute as little as possible to the sum total of atmospheric pollution.

Although I do not agree that the Englishman's alleged penchant for the open coal-burning fire is a serious bar to progress in the matter of domestic smoke abatement, I am very definitely of opinion that unless and until there is an adequate supply of smokeless fuels available to the public at a price comparable with that of bituminous coal, our road to atmospheric purity will be somewhat stony and the journey tedious.

It is often stated that public opinion must precede legislation to some extent if the latter is to be successfully administered. The truth of that statement was, I suggest, exemplified by the great housing propaganda which was organised at the commencement of the slum

clearance campaign, and similar action in respect of domestic smoke abatement is I believe essential in that it would create such a demand for smokeless fuels as would ensure their production in sufficient quantity and at such a price as to compare more than favourably with that of raw bituminous coal. Then indeed would be the time to press upon the Minister of Health the necessity for passing such legislation as was necessary for the prohibition of the use of soft coal in domestic fireplaces.

Meantime I suggest that the action recently decided upon by the Manchester City Council in an endeavour to create a "smoke conscious" mind in its citizens and a desire for smokeless fuels, is more likely to produce good results than the mere passing of condemnatory or restrictive resolutions.

The object of this series of papers upon smokeless equipment in housing schemes is I should imagine two-fold. In the first place it is desirable that we should arouse not only the interest but the enthusiasm of all those persons who will be directly or indirectly responsible for the erection of hundreds of thousands of new houses during the next few years. Among these and undoubtedly occupying pride of place, are the members on the Councils of the various local authorities who have large house building schemes to carry through, together with their advisory technical officers. There is also the private architect, and builder—especially of the speculative type who is responsible for the building of large numbers of small houses. In the second place it is essential that we should stimulate the interest of the general public which includes the potential occupants of the houses to be built in the near future.

SOLID SMOKELESS FUELS.

Before dealing with equipment it is well that we should consider what solid smokeless fuels suitable for domestic uses, are available. Of all natural fuels Anthracite is the one with the strongest claim to be considered smokeless. Oil fuel, although it can be burned without creating smoke is more suited to large industrial plants than the small domestic installation and is therefore little used. By far the greater proportion of solid smokeless fuel is used in the form of coke, which may be divided into three main categories as follows:—

1. Graded Gas Coke.
2. Low Temperature Coke.
3. Coke Oven Fuel.

EQUIPMENT—ANTHRACITE.

Although not extensively used on account of its high price and low volatility, anthracite can be burned successfully in an open grate. As with other fuels of low volatile content however, in order to obtain the best results it is necessary that there should be a good draught in order to obtain speedy ignition, whilst the grate bars should be widely spaced—not less than $\frac{1}{2}$ " apart. Anthracite is, however, most com-

monly used in closed and semi-closed stoves for central heating and domestic hot water purposes where its efficiency and adaptability is unquestioned. It has an unique advantage in that it does not "jam" or "hold" but alawys moves forward into its appointed place, as the fire burns. An anthracite fire thus naturally consolidates itself and requires the minimum of attention. This quality is due to the fact that every piece of fuel is naturally rounded off, smooth and polished. There are numerous stoves and boilers upon the market suitable for burning anthracite or coke, such as the "Kooksjoie," "Cookanheat," "Ideal," etc. I have, however, obtained no information that anthracite is used in any housing schemes, probably on account of its cost—about £3 per ton—and also because it is mostly used in connection with central heating which is not generally adopted in this country and certainly not in the artizan type of house. As I believe anthracite fuel is more popular in the south, it may be that some of our southern friends will be able to give information as to its use in housing schemes, particularly where large blocks of flats have been erected.

GRADED GAS COKE.

Gas supply authorities are by far the largest manufacturers of solid smokeless fuels, and high temperature gas coke, manufactured and graded for domestic heating, is an ideal fuel for use in housing schemes, and it is at present being very largely used. Although far from being as smooth as anthracite, the process of grading does to some extent round the pieces off so that the coke moves forward into its working place with the result that in central heating and water heating, automatically controlled boiler and other furnaces, the replenishment of fuel is only necessary once per day and the removal of the ash once per week.

For use in an open domestic grate best results are obtained with wide spaced bars sloping from front to back with some rocking arrangement to facilitate the removal of the ash, whilst a good draught is essential. From my own experience of the burning of this fuel, however, I must confess that what I have just stated is more of a concession to those individuals who claim that gas-works coke cannot be burned successfully in an ordinary domestic grate, than a belief that special types of grate are essential. I do, of course, agree that in the open kitchener type such as the Yorkshire range, coke cannot be burned successfully. In the "Well" type of grate, however, and especially where the sides and back are formed of refractory material, I have found local gasworks coke to burn so successfully that it is difficult to imagine that it could be improved upon.

There are upon the market many grates specially designed for the burning of this fuel in an open fire, such as the "Ure," "Yorkdale," "Metro," "Kaye," "Eagle," etc. As it is impossible for me in a short paper to describe in detail the construction of each of these, I only propose to refer to their salient features:

The "Ure" grate is of the back-to-back type and not only provides in the living room a modern open fire grate with boiler at rear, but also provides in the scullery or kitchenette a cooking oven and hot-plate. The grate is so designed as to burn coal or coke, and a gas poker is provided as a means of lighting the fire when coke is used. When desired a special coke-burning grate is supplied with a fixed gas burner or gas poker. The one fire heats the living room, and furnishes the heat necessary to provide hot water and the means of cooking, by an appropriate arrangement of flues, dampers, etc. Over 80,000 of these grates are in use, the following Corporations having installed same in their new housing estates:—Leeds, Manchester, Glasgow, Cardiff, etc.

The "Yorkdale" grate is also of the back-to-back type and may be obtained with the special coke burning grate provided with adjustable gas burner. This grate is very similar to the "Ure" and is now being fixed in some of the new houses erected by the Leeds Corporation. The fuel consumption varies according to heat demands, but generally speaking can be said to be about 4-lbs. of coke per hour when used for all purposes.

The "Metro" grate is specially designed to burn high temperature coke in an open fire, and is provided with firebars sloping from front to back in order to ensure a good depth of fire which consolidates itself as it burns. It is also fitted with the usual gas burner. This type of grate is very popular in the South of England and over 24,000 have been fitted in the South Metropolitan Gas Company's lighting area alone.

The "Kaye" grate is also designed for the efficient burning of gas coke in an open fire. In this grate there is a "rocking bar" attachment which allows the ashes to fall into the ash tray, in addition to the fixed gas burner for ignition purposes. This grate is extensively used in and around London.

The "Eagle" gas coke grate is yet another appliance which has found much favour in the North of England, having been fitted in such towns as Oldham, Stockport, Rochdale, Halifax, etc. It is suitable for the heating of rooms by means of an open fire at the back of which hot water boilers may be fitted. A gas burner and "rocking bar" attachment are also provided. A combination grate—open fire and oven—is also supplied, whilst the "Eagle Coke Range" is constructed to supply heat for room warming—by opening the hinged and lagged fire door—hot water, and cooking purposes. A feature of this range is the thermostatic flue control which is situated in the flue outlet for the purpose of ensuring that excessive temperature and waste of fuel will not occur through careless use of the damper controls.

The "Ideal Cookanheat" has been upon the market very many years and the Sculcoates Housing Estate, consisting of approximately 2,000 houses, is largely if not entirely fitted up with these ranges. In this range there is not only heat provided to the room in which it is

fixed, but it is also supplied by the boiler inset to other rooms by means of radiators, whilst an oven is also heated by the same fire.

In all the grates and ranges referred to it is most important that the coke used should be graded, a suitable size being not less than one inch or greater than two inches. Another important point which should be borne in mind by all gas undertakers who desire to sell or increase their sale of gas coke, is that the modern house is rarely—if ever—supplied with fuel storage accommodation upon a generous scale, and as coke is—weight for weight—twice as bulky as coal, frequent deliveries must be provided. In Halifax gas coke is delivered to customers weekly with unfailing regularity, whilst the use of coke is further encouraged by supplying it in paper bags to shops for sale over the counter. Leeds Corporation Gas Department supply sample bags of coke to those tenants occupying houses fitted with back-to-back ranges, in order to encourage them to use a smokeless fuel.

LOW TEMPERATURE COKE.

There is little one can say about equipment for the burning of this excellent smokeless fuel, as it is truthfully claimed that it can be successfully burned in any type of modern grate. All that is necessary to obtain best results—and this applies to every solid fuel burning grate—is that the grate is designed so as to provide easy ignition and throw the maximum radiant energy into the room as quickly as possible. Factors at present militating against the more extended use of this fuel are that in the first place the supply does not meet the demand for it, and secondly the price is much too high for it to be generally adopted by persons of the working class. To-day in Halifax the price is 46/- to 48/- per ton, whilst in other towns further from the carbonization works, the price must be inevitably higher. This compares most unfavourably with an ordinary priced coal and is much more expensive than gasworks coke which of course being locally produced carries no heavy transport charges. As previously stated, I believe the price of smokeless fuel to be the most important factor determining its use for domestic purposes. The statement made re the necessity for frequent and regular delivery of gasworks coke on account of the lack of storage accommodation in modern houses applies with greater force to low temperature coke, as it is not only equally bulky, but much more friable and therefore more susceptible to deterioration during storage.

COKE OVEN FUEL.

Although coke ovens can now be constructed to produce besides high, medium and low temperature coke, there is only a small quantity of medium and low temperature coke available for domestic use, and the price of this is much too high, even if available, at places other than those adjacent to coke oven works. The high temperature variety which contains from one to two per cent. of volatile matter can be most satisfactorily used in enclosed stoves, boilers, etc., owing to the

better control of air inlets. Until there is a much greater supply of medium and low temperature coke oven fuel available that will in price bear comparison with coal, there is little likelihood of its extended use in open grates. When this is available, the type of grates already described will be suitable for the burning of such fuel.

SUMMARY.

To summarize therefore, it would appear that so far as the use of solid smokeless fuel equipment for housing schemes is concerned, there is at present at any rate, the greatest scope for that equipment designed to burn graded gas coke. The National Smoke Abatement Society is, however, entirely indifferent as to the type of fuel used for either domestic or industrial purposes, provided it be smokeless, and welcomes any advance that may be made in the manufacture, marketing, and extended use of any such fuels, together with any improvement in the design of equipment for the use of same. Progress in the direction of smoke abatement has in the past been slow; to-day there is a common and much greater appreciation of the benefits to be derived from clear skies. To-morrow will perhaps witness a complete realization of our ideals.

DISCUSSION.

The Lord Mayor, Alderman H. J. Maggs, J.P., the Chairman, said that Bristol was fortunate in that it did not own the gas undertaking as well as the electricity undertaking. The two were not under the same control and therefore there was a healthy competition, which benefitted consumers, between them.

The papers that were to be presented dealt with the problem of domestic smoke, which, although he had to confess a liking for a coal fire, was of the greatest importance.

After the three papers had been read the Lord Mayor declared the meeting open for discussion.

Mrs. A. J. Newman (Electrical Association for Women) said she was representing some 9,000 housewives, and she would like to thank Mr. Francis for his paper. He had given them absolute facts in the part of his paper dealing with the domestic sphere, and had certainly not overstated the case for electricity on the economic side. They, as an Association of housewives, watched costs very keenly, and there was no question at all of the ability of the average artisan town dweller to pay for the amenity of electricity.

Mr. Francis had spoken of fuel as being still the cheapest form of providing continuous heat, but did the small house want continuous heat in these days of cooking other than by fire? The woman who had to manage her house by herself could not always be in the room with the fire, and she also had to go out, and so if a fire was lighted in the morning it was probably banked up most of the day

and caused much more of the smoke which they deplored. The immediate heat given by electricity at any required time was just what this woman wanted.

She was not going to agree with Mr. Francis, or it appeared with any of the other speakers, about perpetuating the idea of the one coal fire. There never had been more than one coal fire burning at a time in the average small house, and if this was going to be retained the cause of smoke abatement was not going to benefit very much.

A gentlemen had spoken that morning about the need for educating future housewives in their schools not to want the open coal fire. Her Association was doing this work in schools and domestic science colleges, as well as among present-day housewives of all ages, and it was the encouraging change of opinion evinced among women wanted in a house the Society had been asked to visit on having their electric fires imitating coal ones) which made them decide that the time was now ripe to set an example in building the entirely flueless and grateless house. Their first attempt at showing what women wanted in houses the Society had been asked to visit on Sunday. The house was not finished but was in a sufficiently finished state, she thought, to be interesting.

A great deal of virtue was made out of the necessity of providing flues in a house to make possible some forms of combustion, but it had to be admitted that they caused draughts. Electricity did not require oxygen for combustion, and therefore did not need special ventilation, but byelaws being byelaws, the house they were building was properly ventilated by ventilating ducts, which dealt with the air all over the room, instead of through one dirty, draughty, ventilator.

Mr. Francis had referred to the cost saved in construction by not having chimneys. The meeting might like to know that they had estimated the saving from that source on their £1,000 house at £40. One-third of the bricks generally required in a house of this size were not used. With the money thus saved, together with that generally spent on mantelpieces, etc., they were helping forward smoke abatement in a practical way, by supplying, included in the price of the house, its electrical equipment, which in this case included nine electric fires.

Certainly planning was not so restricted with electricity. Electric fires could be on any wall, and the absence of chimney breasts made much more room inside the small house. Needing no flues electricity could not possibly be emitting anything harmful for the inside or outside of the house, and surely that was one very successful way of dealing with atmospheric pollution.

Alderman J. H. Waddington (Halifax), said that smoke abatement must be looked upon from all sides, and with unity. The efforts of this united organization were to eliminate smoke by the

disuse of raw coal. They had to admit that the domestic fire was the great stumbling block. While electricity was most useful for lighting it was out of the question for the working man to use electricity for cooking and heating purposes. In Halifax there was one solid fuel fire in every house, and that one fire was emitting little or no smoke when smokeless fuel was used and this description of fuel was available at a low price. He considered it essential that the working man should have an open fire, and it was the privilege of the Corporation to see that he was provided with a smokeless fuel that could be burned in his own grate.

Councillor Goldsmith (Camberwell), said that in his area the chief housing authority was the London County Council. He believed that there was a place in every home for the open fire, also there was a great deal to be said in favour of coke as a suitable smokeless fuel for working class houses. During the autumn and winter one could see a large coke fire burning in the entrance of the London County Hall, but in a number of flats and dwelling houses of the same authority the tenants were burning raw coal in the usual type of fire grate.

In his own home the daily cost of burning the Gas Works Graded Coke in a modern coke fire was 5½d. per day (15 hours). He considered it the duty of the Corporations to encourage the use of smokeless fuels in the homes of the public.

The equipment of working class homes it should be practicable to ensure that the cost of use was within the reasonable limits of the tenant's purse.

Councillor Alex Munro (Scottish Branch, N.S.A.S.), said that he had been Convenor of both the gas and electricity committees of the Glasgow Corporation. He said that gas was good for industrial purposes only, and should not be used in the houses at all. It took 12 to 15 minutes before the products of combustion were carried up the chimney with a gas fire, and with the use of a gas cooker the products of combustion penetrated into the food to a depth of $\frac{7}{8}$ of an inch. He considered that a man's breakfast could be cooked more quickly and easily by electricity than by any other means. With electricity it was only necessary to have one change of air per hour, per room, because there were no products of combustion either from electrical heating or cooking.

Mr. B. J. Bell (British Commercial Gas Association), said that the main factor in smoke abatement was that the atmosphere should be clear in all our large cities, and that could only be done by putting to the best use all the methods available. The solid fuel fire was used for a large number of fires each day, and therefore a smokeless fuel fire was an absolute necessity. The three papers which had been read had shown three available and good economic conditions, and had shown all the different types of fires available to the public for

the burning of smokeless solid fuel. He considered it the duty of the Society to promote all the methods mentioned by the speakers.

Mr. T. E. Birtwisle (Sanitary Inspectors' Association), said the readers of the papers had given them much information on the subject. He did not agree, however, with the views put forward and the advantages claimed in respect of flueless houses, and as a sanitary inspector he would have no hesitation in bringing into operation the provisions of the Housing Acts, where houses or rooms were not provided with adequate means of permanent ventilation. He further considered that 3/- per week for lighting and cooking by electricity was more than the average working man could afford.

The advocates of the flueless house appeared to give no thought to the disposal of wet and readily putrescible refuse from the kitchen. The housewife was rightly asked not to place such material in the dust bin, and collection was generally made once a week. What then was she to do with it? He strongly advocated at least one open fire in a house.

There was much to be said in favour of both gas and electricity, and he failed to see why these two public services should be in a state of rivalry. They had each their place, and the one should be regarded as being complimentary to the other, or the one being used to produce the other.

Dr. W. M. Frazer (Liverpool), said it was not the function of the Society to decide as between several methods of heating or cooking in particular houses. What they wanted to do was to see that houses were constructed which did not, on account of the processes which went on inside them, result in the pollution of the atmosphere. He did not think that those who advocated electricity had taken sufficient notice of the cost and the very important factor of ventilation. He rather doubted whether the suggested saving would really be secured if they got a satisfactory ventilating apparatus. Would it not be desirable to ask the Executive Committee to go into the whole question and prepare a scheme, taking into consideration all the types of heating and cooking in the cottage and other types of houses. They would be entirely free to decide on gas or electricity or solid smokeless fuel, and possibly in the end might recommend them all.

Mrs. Mary Higgs asked about the working class house that was not in the slums, but belonging to the unemployed. There should be means of supplying smokeless fuel to the ordinary working man, and they ought to press forward some smokeless means for people who could not afford to change firegrates, instal gas or electricity, and yet wished to burn smokeless fuel.

Mr. R. H. Clayton said that the controlling feature in the heating of a house was the cost, and coke was the cheapest heating agent. Ninety per cent of the city domestic smoke was produced in the

houses of the poor man, and in such houses coke could be most readily introduced and paid for.

In continental cities the refuse was collected daily, not weekly, as in our English cities; and therefore it was essential that it should be burned.

He did not agree with the suggestion put forward by Dr. Frazer, and said that it was not the Society's work to decide which were the best means of heating a house.

He referred to the suggestion made by Mr. Gandy and himself in their joint paper read at the Sheffield Conference, and again suggested that there should be a Department in large Corporations to deal with the problem of smokeless heating and the concomitant ventilation data necessary to ensure success.

Councillor Hardie (Edinburgh), said that most women in Scotland preferred an open coal fire. He referred to the support given to the resolution regarding the Manchester City Council, but did not think that they should ask the Corporations to equip houses with electricity as a whole.

In Edinburgh gas was supplied through a grid system to an outside authority, which enabled the surrounding villages to use gas, but, if all was electricity, what was to happen if there was a failure of supply? Therefore it was essential that all new developments should be encouraged.

Mr. Charles Gandy said that he agreed with Mr. Clayton that the investigation suggested by Dr. Frazer was a matter for the municipalities rather than for the Society. In recent years municipalities had been spending thousands of pounds on housing, and nothing was more important to good housing than pure air, and clean and healthy surroundings. It was, therefore, well worth while for municipalities to assist their Housing Departments by a careful study of the best methods of avoiding smoke on new Housing Estates. Local authorities had full power to expend money on such investigations.

Councillor W. Asbury (Sheffield, Rotherham, and District Smoke Abatement Committee) said it would appear from the discussion that the open fire, in all circumstances, was to remain. They were being led to believe that the people did not want modern methods. He considered that public opinion needed to be educated. Electricity was most decidedly the most popular in the modern home, and he expressed the hope that it would 'hold the field,' but he considered that both gas and electricity could be sold less profitably, in order to let the public have the benefit. He referred to the resolution passed at the Glasgow Conference last year, and again stressed that houses should be erected with means for smokeless devices, and ample accommodation for the storing of smokeless solid fuels,

Mr. Geo. S. Francis (British Electrical Development Association), briefly replied to the points in his paper that were raised in discussion.

Some of the points raised in the discussion, he said, seemed to assume that the methods of the past were permanent and at best could only be refined or improved. It had to be remembered however, that the technique of the 20th century had made it possible to conduct the normal business of life in entirely new ways and whenever these new ways were found to be superior we should display less hesitation than was customary in forsaking older and dirtier methods of the past. This was particularly true with regard to the electric production of heat which completely avoided the problems of combustion with which other methods are involved. With the various methods of electric heating that were now at their disposal, reliance on the open fuel fire was no longer a necessity and would soon be regarded as a nuisance.

With regard to the question raised about the disposal of refuse, even in modern houses that were otherwise well-equipped with electrical appliances, there was usually one fuel fire of some description or another and until more effective means of public disposal of household refuse were in operation, this was available for consuming combustible rubbish.

Mr. G. L. Jennings in reply said that there were not many points raised in the discussion of his paper to answer, but the point had been raised that it would be well if the gas and electricity were not in antagonism but were combined, both working to the common cause. He pointed out that in many places the gas and electricity were jointly owned and worked together. There was no antagonism towards electricity, in fact he had many friends in the electrical industry who had themselves pointed out the desirability of fusion. It remained to be seen what progress could be made in this direction in the future.

A delegate had suggested that if electricity was used no ventilation was necessary; to that he was most definitely opposed. Ventilation as given by the chimney was advocated by every doctor and every ventilating expert. It would be most harmful to breathe air already contaminated from the lungs.

The question of sulphur referred, he thought, to the burning of coke and not to gas. The sulphur in gas was negligible. The penalties of sending out sulphur were very heavy and practically no sulphur was found in purified coal gas.

Referring to the ventilating properties of gas, he said that the ventilation of the Albert Hall, St. George's Hall, Liverpool, and Colston Hall, Bristol, were entirely carried out by means of coal gas.

The remarks made by Councillor Munro of Glasgow were unfounded in fact, and he could not regard them as being made seriously.

Mr. John W. Beaumont, in replying to the discussion, said that he had really nothing to answer. He said that the discussion itself had exemplified the fact that there was a great divergence of opinion as to what was the most suitable type of smokeless fuel to use. It was therefore obvious that the time had not arrived when they should recommend one type of heating above any other. Until it became clearly evident that a particular form of smokeless fuel was better than any other, they would proceed on sound lines by encouraging the use of all types.

The Session concluded by a vote of thanks to the Lord Mayor for presiding and to the three speakers for the papers they had prepared.

Saturday, September 21st. Conference, 3rd Session.

SMOKE AND THE COUNTRYSIDE.

By Dr. A. G. RUSTON, B.A., D.Sc.

*Lecturer and Advisory Economist, Department of Agriculture,
University of Leeds.*

Chairman: Professor GEORGE A. BUCKMASTER, M.D. (Oxon), F.R.C.S.,
D.P.H. (Oxon), of Bristol University.

I feel that I owe an apology to the Conference for reading a paper dealing with a subject on which I have done little or no serious work for the last 15 years.

It is now 30 years ago almost to the day since I came up from Reading on my appointment to the staff of the Department of Agriculture in the University of Leeds. I shall never forget my journey north between Sheffield and Leeds, through country naturally beautiful but rendered hideous by the hand of man. The trees in many cases, like Dean Swift, dying atop; the hedge rows a blot on the landscape. It was that journey that made me for the first eight years of my stay in Leeds devote almost the whole of my spare time to a study of the problems of smoke pollution, particularly as they affected the agriculture and horticulture of the county in which I was to work. I quickly found that Professor Cohen had been working in the same field in other directions for many years, both in Manchester and Leeds, and I should like to pay my tribute to the help and inspiration I obtained from him; no man has done more for the advancement of Smoke Abatement in the town and country than that many sided, gifted and lovable man whose recent death we all deplore.

A. University Farm, Garforth.

From 1906 to 1909 investigations were carried out as to the amount of atmospheric impurities brought down by the rain on the University farm at Garforth.

The farm is situated on the outskirts of the urban district of Garforth, some six miles due east of the great industrial city of Leeds, and on the north-eastern edge of the Yorkshire coal-field. The prevailing winds are westerly, and hence convey much of the impurity of the Leeds atmosphere over the farm. There is further local contamination from the coal-mining districts to the south and south-east, more particularly from two collieries situated respectively about one mile and a half from the centre of the farm. To the north-west, and north-east is a large tract of strictly rural character, so that from these quarters the atmosphere of the farm is not subject to serious contamination.

Previous analyses carried out at Rothamsted go to show that the yearly rainfall carried down there on the average roughly $3\frac{3}{4}$ -lb. per acre of nitrogen in the forms either of ammonia or nitric acid;

14 $\frac{3}{4}$ -lb. of chlorine as chloride;
and 17 $\frac{1}{2}$ -lb. of sulphuric acid (total free and combined).

It is most probable that these results may be taken as typical of the rain falling in the essentially rural parts of the country, fairly remote from the sea, but they do not hold good for the large tracts of agricultural land situated in the smoke infested localities, so extensive in area in Yorkshire and many other parts of the country.

The total amount of *Nitrogen* brought down by the rain amounted on the average of the three years to

8.37 lb. per acre per annum, as compared with

3.84 lb. at Rothamsted;

the annual amount of *Chlorine* to

20.89 lb. as compared with

14.87 lb. at Rothamsted.

the annual amount of *Sulphuric Acid* to

95.7 lb. as compared with

17.41 lb. at Rothamsted.

Though the farm is situated six miles from Leeds, the principal, though by no means only, source of smoke pollution, the rain was infinitely more acid, contained three times as much nitrogenous pollution, and five times as much sulphur pollution as did the rain falling in a purely rural area like Rothamsted.

B. City of Leeds.

During the next year detailed analyses were made of the amount of smoke pollution at 10 stations in different parts of Leeds, within a four-mile radius of the town hall, these stations being situated in industrial, residential, and suburban areas.

The *influence of the industrial centres* upon the amount of suspended impurities stands out quite conspicuously, as they were twenty times as abundant in the chief industrial centres as they were in the purer atmosphere of a station some four miles due north-east of the centre of the city.

The *influence of the prevailing winds* was found to be most striking. The prevailing winds in Leeds are west and south-west. Two stations, therefore, were taken both roughly the same distance from the centre of the city, both overlooking the industrial Kirkstall section of the Aire Valley, one from the east and the other from the west, and it was interesting to find that, while the suspended impurities at the station in the direction of the prevailing winds amounted to 660 lb. per acre, they were only 350 lb. per acre at a similar station on the other side of the valley.

INDUSTRIAL AND DOMESTIC SMOKE.

At all the stations an appreciable amount of tar was found in the suspended matter, the amount being greatest in and near the industrial area, and diminishing rapidly as we pass into the residential and suburban areas further north.

It is interesting to note that, while the suspended matters in the suburban areas were smaller in amount, they were richer in tar than those of the industrial areas, tar forming 17 per cent. of these total impurities in the residential areas and only 4 per cent. in the industrial. There is, therefore, a characteristic difference between the contamination arising from the factory shaft and that attributable to the very imperfect combustion of the domestic range.

To test this the same coal was burnt under ordinary domestic conditions in one of the class rooms on the ground floor of the University, the chimney of which had previously been swept, and also burnt in the boiler under factory conditions. The differences between the domestic and boiler soots thus obtained from the same low grade coal were striking and instructive. The domestic soot as compared with the boiler soot was rich in carbon and the volatile products such as tar, ammonium chloride, ammonium sulphate and arsenic, and poor in ash.

ANALYSIS OF SOOT FROM UNIVERSITY.

	Coal	Soot	
	%	Domestic %	Boiler 70 ft. up %
Carbon	69.30	40.50	21.80
Nitrogen	1.39	4.09	1.18
Ash	8.48	18.16	66.04
Tar	—	25.91	0.80
Sulphur	1.74	2.90	2.58
Chlorine	0.27	5.19	1.46
Acidity	0.00	0.37	0.58
Arsenic	0.0096	0.078	0.075

Even domestic soots vary with the type of grate and amount of draught. The same coal, a good household coal, if anything a bit gassy and caky, was burnt in the kitchen and dining room of my own house, the dining room grate being a slow combustion one, and the kitchen an open grate with strong draught, the fire often roaring up the chimney.

SOOT FROM MY OWN HOUSE.

	Coal %	Soot	
		Kitchen %	Dining Room 20 ft. up %
Carbon	76.8	52.3	34.1
Nitrogen	1.72	4.11	6.04
Ash	1.80	17.8	4.97
Tar	—	12.5	37.2
Sulphur	0.79	2.20	2.56
Chlorine	0.25	1.35	6.41
Acidity	0.00	0.28	0.55
Arsenic	0.0062	0.0016	0.0068

It will be seen that the higher temperature of the kitchen fire, and the increased draught, increased the amount of ash and decreases that of the volatile products when compared with the dining room sample.

C. District Round Leeds.

Two years later similar investigations were carried out at stations situated within a radius of 7 miles from the centre of Leeds, concentrating to a large extent to the north and north-east where the coal measure soils have, to a large extent, given place to the Millstone Grit, and the country become almost entirely agricultural in character.

The results showed quite distinctly

- (a) that the effect of the smoke polluted atmosphere of Leeds could be easily traced into this agricultural area for a distance of 7 miles;
- (b) that the prevailing wind was again a factor of quite marked importance;
- (c) that apart from the gross atmospheric contamination due to the industrial conditions of Leeds, minor sources of contamination could be also traced to the domestic smoke of each residential village and homestead, as well as to the railway running through the district.

D. Effect of Smoke Pollution on Plant Life.

After having, within a radius of 7 miles from the centre of Leeds, obtained detailed information as to the nature and amount of smoke contamination in the different districts, the next few years were devoted to a study of the effects of that known contamination on the growth and welfare of crops and stock. Briefly it was shown that the main factors in smoke pollution which prejudicially affect vegetation are—

- (i). The smoke cloud limiting the available sunshine.
- (ii). The tarry matter coating over the leaves, choking the stomata, and checking, if not preventing, the natural process of transpiration and assimilation.
- (iii). The presence of free acids in the air tending generally to lower the vitality of the plant.
- (iv). The effect of the free acids falling on the soil and limiting the activity of the soil organisms, principally the all important nitrifying ones.

The last factor can fortunately be very effectively dealt with by a simple application of lime, while the first two can only be met by checking the output of smoke and making every effort to lessen the air pollution, which is the ruin of many of our crops.

E. Smoke Damage Not Confined to Industrial Areas.

The effects of coal smoke contamination are naturally experienced with a far greater intensity in the towns than in the countryside, but smoke knows no boundaries, and its consequences may frequently be seen in rural districts, especially those lying near to or between industrial or densely populated areas. Practically the whole of the countryside in South Lancashire and Yorkshire is visibly affected, as if by a blight, by the smoke from millions of neighbouring factory and domestic chimneys. Experimental evidence goes to show that one would not be very wide of the mark in stating that, as far as the householder is concerned, for every ton of coal he buys one hundred-weight goes up the chimney unconsumed; while as far as the factory is concerned there is at least a loss of one stone out of every ton of coal purchased.

In this way nearly $2\frac{1}{2}$ million tons of soot escape annually into the atmosphere of this country in the form of smoke pollution. Of this a certain amount falls *in situ*, but the greater bulk is blown away, polluting the atmosphere for miles round all over our great manufacturing and residential areas.

Smoke from industrial England has been observed as far away as Valencia Island on the West Coast of Ireland; the smoke drift of London is frequently seen by air pilots over the Channel and Northern France; a soot fringe on the edge of Coniston Water—derived from Lancashire and the West Riding of Yorkshire—has been photographed by Professor Cohen; it has been alleged that the sheep on the Isle of Man turn darker in colour when an east wind blows across from Lancashire.

Smoke, then, spreads far and wide, and although its effects are lessened the further away from its source its travels, it cannot escape the attention of those who are concerned with the preservation of the country side.

The Departmental Committee on Smoke and Noxious Vapours Abatement, in their Interim Report, wrote as follows on the subject of smoke and vegetation:—

“There can be no doubt that smoke and noxious vapours have a highly injurious effect on vegetation and on agriculture generally. It is a matter of common observation that in and near industrial and densely populated areas dead and dying trees are a feature of the countryside.

Among trees, conifers are those most adversely affected, but plant life in general is injured and shortened by smoke. Instances have been brought to our notice to show that the heavy deposit of acid soot on pasture cause damage to live stock in various ways.

The same causes, we are informed, tend to deteriorate the quality of milk produced in or near smoky districts.”

The economic effects of smoke pollution, with its deposits of tar and acid upon the grassland in the smoke areas, are enormous. The leguminous plants and finer grasses disappear, and the herbage usually consists mainly of bent, Yorkshire fog, woodrush, sorrel, yarrow and moor grasses, while the feeding value of the coarse grasses and weeds which survive is considerably reduced.

This again is reflected in the diminished stock-carrying capacity of the land, and land which some thirty years ago was carrying two bullocks to the acre, will now carry less than one head of stock to three acres.

It is shown in many cases in an economic loss of rent. Land near one of the coal mines in the Barnsley district was rented in 1887 at 52/6 per acre. In 1890 that rent was lowered to 37/- per acre, on condition that no claim was made for damage from smoke pollution. In 1900 the rent was again lowered to 20/- per acre, and in 1902 further reduced to 10/- per acre. At the present time this land consists of little more than derelict grassland or barren arable land growing practically nothing but stunted sorrel and spurrey.

Not only is the milk in our industrial areas produced at a higher cost per gallon, but the actual composition of the milk so produced is undoubtedly detrimentally influenced indirectly by smoke pollution.

It has already been pointed out that the acid rains tend to neutralize the free lime present in the soil; the calcium sulphate thus produced being washed out and finding its way into the drains. This naturally tends to leave the soils poor in "Available Lime." Practically none of the soils on the farm at Garforth contain more than 0.2 per cent of free lime, most of them considerably less. If there is a deficiency of lime in the soil it is only natural to expect a deficiency of lime in the crops growing on that soil. For bone formation the ratio of lime (CaO) to phosphoric acid (P_2O_5) should be approximately 1 : 1. In green foods like grass, hay, turnip tops, etc., lime is in excess, in the cereals and concentrated foods phosphoric acid is in excess. The ratio of lime to phosphoric acid in a normal meadow hay is approximately $2\frac{1}{2}$: 1; in a normal seeds hay is approximately $3\frac{1}{2}$: 1. Thirteen different samples of hay produced on the farm at Garforth have been analysed, and the average resulting ratio of lime to phosphoric acid in these samples has been not 3 : 1 but 1.12 : 1.

Since hay and grass are practically the only foods fed to cows in which the lime present is in excess of the phosphoric acid, and since the ratio phosphoric acid to lime is

in Linseed Cake	4 : 1
in Cotton Cake	10 : 1
in Coconut Cake	3 : 1
in Palm Nut Cake.....	4 : 1
in Ground Oats	7 : 1

It is to the hay and grass that the cow must look to make up the

deficiency of lime in other foods. In a normal milk the lime and phosphoric acid are usually present in approximately the same proportions as are required for bone formation, and the ratio of lime to phosphoric acid in a normal milk approximates to 1 : 1, and rarely falls below 1 : 1.25. Some two or three hundred samples of milk produced on the farm at Garforth have been analysed, and all have shown a considerable deficit in lime, the average ratio of the samples analysed being not 1 : 1 but 1 : 1.54, and in some cases being nearly 1 : 2.

This poorness in lime of the milk produced in our industrial areas is a matter of considerable importance, and undoubtedly is one contributory factor to the prevalence of rickets and bone trouble in the children reared in our manufacturing towns.

Robert W. Ashcroft, late of the Food Production Department of the Board of Agriculture, in his book "The Conservation of the Nation's Vegetation," writes:—

"In a smoke infested area the grass is coarse and poor in quality, and farmers find it difficult to provide adequate grazing for their cattle. This is a matter of considerable importance to the agriculturist. The acid present in the smoke lowers the nutritive value of the grass, with the result that the farmer is obliged to incur additional expense in the purchase of food stuffs for feeding his stock. The soil in these areas will also suffer loss of lime for the same reason, and, as the grass itself will be poor in this substance, the lime content of milk obtained from cows feeding on pasture close to large towns will tend to be lowered. Lime is essential to the well-being of young stock, and its absence in pastures near to towns accounts very largely for the difficulties in breeding sheep. Dr. Ruston has kindly sent me some very interesting notes bearing on this matter, in which he has called my attention to the high percentage of loss of lambs due to abortion in various parts of Yorkshire where the sheep were feeding on grass damaged by smoke."

It is clear, therefore, that in rural districts adjacent to industrial areas the vegetation and livestock is adversely affected by the smoke drift from the towns, not only spoiling the beauty and freshness of the natural scene, but adding materially to the difficulties of farming.

One of the most noticeable effects of smoke in a city is the blackening and corrosion of the stonework of buildings. Manchester Cathedral is an excellent example, while even the new Anglican Cathedral at Liverpool is showing traces of decay through the action of the acid-laden smoke deposit. Sir Frank Baines, the eminent architect and Director of H.M. Office of Works, closely studied this aspect of the problem, and found that smoke is also affecting stonework in historic buildings in rural districts. In the *Journal of the National Smoke Abatement Society*, Spring, 1931, he writes:—

"Many of the Yorkshire abbeys and also historic buildings in the

Wye Valley, far removed from the industrial centres of the Midlands and the concentrated industry of South Wales, show increasing signs of stone decay, primarily due to the corroding presence of atmospheric acid. It is becoming increasingly evident that comparatively small proportions of sulphur acids derived from the combustion of raw coal will, in time, cause complete destruction of the surface of historic buildings, far removed from centres of industry."

This is confirmed by recent experiments on the presence of sulphuric acid in the air at Rievaulx Abbey in North Yorkshire. The quantity is appreciable, and is much greater in winter than in summer, showing that the effects of the greater consumption of coal during the winter months are discernible even many miles way from any large town or centre of industry.

A further aspect of the smoke problem is of importance, even though it affects the countryside only indirectly. The smoke of our towns and cities is one of the principal factors in producing dirt, drabness, and gloom, and has, of course, serious effects upon health. It makes town life less pleasant and desirable and is unquestionably a potent cause in the increasing exodus from the towns and consequent haphazard building in rural areas.

Smoke abatement will thus not only benefit the country directly, but indirectly, by giving cleanliness and pure air to the towns themselves, will assist in preventing the undesirable and illogical outwards sprawl of suburbs.

DISCUSSION.

Professor George A. Buckmaster, the Chairman, in opening the session, said that Bristol was a remarkably clean place. He knew Manchester and the conditions in that city, and in particular had been surprised at the effects of that atmosphere upon leather and leather upholstery and other leather work.

It was a pity, he felt, that he did not know of any specific disorder or damage to health due to smoke, even though it was incontestable that smoke was harmful. Even coal dust did not seem to do any harm. The lungs of a man living in a smoke-laden atmosphere, nevertheless, were black instead of pink, and were, mass for mass, heavier than those of a countryman, and the general effects of a smoky atmosphere upon city people were obvious.

The aesthetic side of the question was of great importance. The aesthetic development of children growing up in a smoky atmosphere was interfered with by smoke affecting all the amenities they should enjoy. Further, the more dirt there was to contend with the less time there was for other things.

After the presentation of Dr. Ruston's paper Professor Buckmaster declared the meeting open for discussion.

Bailie W. Brownhill Smith (Scottish Branch, N.S.A.S.), in congratulating the speaker on his excellent address, said he had known Professor Cohen for many years, and had made great use, in lectures, of the valuable work carried out by Dr. Ruston and Professor Cohen. He referred to the statement made by Dr. Ruston in his paper regarding the journey from the South to the North of England and the increasing smoke as he journeyed, thirty years ago; but he, Bailie Smith, had noticed that on his journey down to Bristol the same smoky conditions still survived, and it seemed that little progress had been made during the last thirty years. He referred to the fact that other countries had many miles of electric railways, but in England they had very few.

He said that on Coniston Water, in the Lake District, there could be seen a scum of soot on the water, being a result of the smoke drifts blown from the manufacturing towns of Lancashire. He quoted a statement made by Dr. Buchanan of Glasgow on his survey of the effect of atmospheric pollution on stone, where he had found a certain kind of bacteria that thrived on atmospheric pollution deposits.

Mr. Geo. S. Francis (British Electrical Development Association), said that he had been informed by agricultural investigators at various centres on the continent that in their opinion at least as much damage was being done to vegetation by the deprivation of the short-wave rays of sunlight, which were unable to penetrate a smoke-laden atmosphere, as was being caused by the chemical pollution for which smoke was responsible. Could Dr. Ruston substantiate this view from his own experience?

C. Councillor W. Hill (West Riding of Yorkshire C.C.), said that he lived in Baildon, Yorkshire, where it was stated that the air was the second best in England. For many years he had been a cricketer in Baildon, and it was found that there, in the heart of the industrial towns (4½ miles from Bradford, 1½ miles from Shipley, and 9 miles from Leeds) a very excellent quality of turf could be grown. Could Dr. Ruston explain how this was?

Mr. James Law (Sheffield, Rotherham, and District Committee), asked if Dr. Ruston could give any information with regard to a disease among trees in the West Riding area? Ash trees and elm trees appeared to be seriously affected, but sycamore, oak, and chestnut appeared to be immune. Had the installation of coke-oven plants at collieries any bearing upon this, or was it due to some other cause?

Alderman D. P. Charlesworth (Wallasey), referred to Dr. Ruston's statement that the effect of atmospheric pollution on the land diminished the stock-carrying capacity of the land, and asked if in Dr. Ruston's opinion this pollution was one of the factors

responsible for the reduction in home-killed meat and increase in consumption of imported meat?

Mr. T. M. Ashford (Glasgow), quoted from the results obtained by the nine gauges erected in Glasgow by the Corporation, which showed how a gauge that was situated in the smoke-drift recorded more atmospheric pollution than another situated on the opposite side of the city. He also quoted the case of a village 35 miles away from Glasgow which suffered from the effects of Glasgow's smoke.

He drew the attention of the conference to specimens of leaves which had been exhibited that year at the Annual Conference of the Scottish Branch of the Society at Stirling, showing that as one travelled inwards towards the smoke-laden city atmosphere, from approximately 25 miles out in the country, the texture and condition of the trees were progressively poorer.

Dr. Ruston, replying to the discussion, said that he had seen clouds of smoke coming from the Lancashire and Yorkshire towns and drifting in one direction, and, with a change of wind, had completely altered their course and drifted in the opposite direction.

He said he could quite understand the point raised by Mr. Francis. The effect of the solid impurities in the air in diminishing the amount of sunlight in one industrial town might be gathered from the fact that the average number of hours of bright sunshine recorded in the centre of Leeds was 1167 per year, as compared with 1402 hours at Adel, some four miles to the north. In other words the smoke cloud hanging over the centre of the town curtailed the duration of bright sunshine by fully 17 per cent. If, however, they measured not the hours of bright sunshine but the actual intensity of the light, they found there was a reduction not of 17 but of 40 per cent. The effect of all this curtailment of light upon vegetation was only too obvious.

The fact that Baildon had such pure air and good turf was accounted for by the fact that it was situated on the side of Leeds which was not affected by the prevailing winds. If it were situated nine miles on the opposite side of Leeds the effect would be reversed.

The moors between Lancashire and Yorkshire were seriously affected by the smoke from these counties, for the sheep were turned black in colour, and the heather would not grow. The smoke drift made a tremendous difference to the conditions of vegetation in the towns.

In reply to the question raised by Alderman Charlesworth, he said he was not able to answer that question, as he was not a Doctor of Medicine but a Doctor of Science, which degree he had obtained through his work on the smoke problem.

The deposit of acid along with soot upon the leaves of plants was probably one of the main causes of the early withering which

was so characteristic of many forms of town vegetation. Ash trees in the newer parts of Leeds retained their leaves some six weeks longer than those in the more contaminated districts. A permanent automatic record was kept by the tree itself in its relative yearly growth, and the presence of any inhibitory effect was shown by a diminution in the size of the annual rings. In one case of which they had a record, on the tree being cut down the narrowing of the rings dated back to the opening of coke-ovens in the immediate neighbourhood some twelve years earlier.

GRIT AND DUST EMISSION FROM A SANITARY INSPECTOR'S VIEWPOINT.

B1

By L. H. DIBBLIN, F.S.I.A., Chief Sanitary Inspector,
Borough of Willesden.

Atmospheric pollution has been talked and written about so much during recent years that except in special circles and amongst certain "air-conscious" people one is apt to think the subject taboo.

A few years ago the public submitted to their persons, their pastures and their privets being continuously clothed and reclothed in road-dust and just waited for the wholesome rain to cleanse them, when the process started all over again.

The advent of bitumistic surfacing of the roads has effected a very considerable improvement, so that the appearance of a watercart is a rarity. In this direction a remedy has been found and applied.

In like manner the travelling public and pedestrian tolerated that all too frequent inconvenience "grit in the eye" from railway engines and coal-driven road vehicles. The electrification of the former in Metropolitan areas and the petrol or electric driven vehicles on the road to-day have somewhat reduced this one-time nuisance.

To-day the aviator graphically describes how he can take his bearings by the pall of smoke over such and such a town and looks forward to the day when his visibility over urban areas will be at least one mile, and so be able to fly with comparative safety.

Despite engineering progress, grit and dust emission to-day arises mainly from steam raising plants, cement works and refuse destructors, and the object of my paper to-day is to indicate atmospheric pollution from the smoke inspector's viewpoint, and to give some personal experiences of the nuisance, the measures taken to minimize the nuisance and the legal difficulties met with.

It is true to say that in the process of coal combustion some solid matter passes out with the gas and that in the aggregate the ordinary coal fires from dwelling-houses emit a larger percentage of smoke than do the factory chimneys, although only 23% of the coal consumed is burned in domestic grates as against 77% in industrial furnaces, the reason being, because the latter are designed to obtain the greatest possible number of heat units per lb. of coal consumed and generally speaking are better controlled to that end. It is also true to say that factory chimneys are emitting less smoke than formerly, largely due to the fact that manufacturers now know that to emit smoke is to waste heat and that with a plant adequate to cope with the peak load, coal suitable for the plant, intelligent firing and proper maintenance, there is no logical reason to waste heat, i.e., money in such a manner. By the Public Health (Smoke Abatement) Act 1926, Section 1, smoke

is defined as including soot, ash, grit and gritty particles, and it is an offence to emit any of them in such quantity as to be a nuisance. It is not necessary to prove that such is a nuisance as it can be a contravention of the byelaw made under Section 2; there is, however, a proviso that it is a defence, except in the case of black smoke. If it be proved, that the "best practicable means" have been taken, the onus is therefore placed upon the complainant to prove that the best practicable means have not been taken. Under Section 2 of the Act some Local Authorities have made a bye-law prescribing that the emission of black smoke for a period of two minutes (in some areas three minutes) in the aggregate within any continuous period of thirty minutes from any one chimney in a building, other than a private dwelling-house, shall be presumed to be a nuisance.

The following experiences may be of interest to my listeners. An electrical generating station, with limited space, installed pulverized fuel furnaces in place of chain grate stokers. Within a short time numerous complaints were received that premises in the vicinity of the works were being subjected to showers of grit. Evidence of this was apparent on the footpaths, foliage, window sills, and even to penetrating the houses through closed doors and windows and spoiling food.

Numbered zinc trays, some two feet by one foot and two inches deep, were placed in suitable positions at given distances and different cardinal compass points from the works. The contents of the trays were collected and weighed daily (allowance being made for any extraneous matter which gained access). Each day these weights and the tray number were recorded together with atmospheric conditions, direction and strength of wind, etc. A microscopic examination of this grit indicated that it was the residue from burned pulverized coal whilst the sizes of the particles showed that the largest and heaviest particles fell in the trays nearest the chimney, correspondingly smaller particles in the trays more distant, and the smallest particles in those trays placed furthest from the works.

These data, accumulated over a period of some twelve months were placed before an eminent K.C., but were not considered "evidence" as nobody could swear that this particular grit came in fact from this particular chimney.

In these circumstances it would appear to be futile to enter into litigation.

Another method of establishing the emission of grit is to obtain sheets of glass, some twelve inches square, smear them lightly with a preparation of tanglefoot (made from oil and resin as used for sticky flypapers). Place the prepared glass at different points around the factory and at other points of the district, i.e., open spaces, residential areas, etc.

After twenty-four or forty-eight hours exposure cover the glass (sticky side) with white paper, on which is recorded date, situation,

etc. This paper will keep the grit in position, prevent running, and show up the grit; comparisons will speak for themselves, but I am not prepared to say that these exhibits would be accepted as evidence.

The usual methods to prevent grit emission fall into three categories: dry grit arrestors, gas washing, electrostatic precipitation.

ARRESTORS.

- (a) A centrifuge consisting of a fan of paddle type is placed in the path of the gases. The dust laden gases enter the fan, pass over specially shaped blades, and as the dust lags it is caught in air pockets formed between the blades, when it is deflected by "V" shaped channels at the periphery into dust chambers formed inside the fan case.
- (b) Gases enter the collector under action of an induced draught fan. This collector is of volute shape with series of truncated cones terminating in a dust outlet. The gases enter tangentially and the casing being volute a centrifugal action is set up. The velocity being increased by reducing area, the heavier particles are thrown outwards and downwards in a spiral path to the conical base outlet.
- (c) Employs the same principle as (b), excepting that the volute duct has a channel into which the grit is thrown, whence it is carried to collecting pockets.

GAS WASHING.

Several methods come under this heading. Two of these systems with which I am familiar are:—

- (a) Specially designed elements are placed in the flue, arranged in a series of lines and so spaced that water overflowing from these elements forms a film of water through which all the flue gases must pass before entering the stack. The grit laden water passes to settling tanks where the grit precipitates; the cleared water is run off and the slurry removed by mechanical grabs.
- (b) Is an adaptation of the same principle. Boards 7" x 1¼" x 10' are fixed in double series and staggered, the boards being spaced 3" to 4" and the series two feet apart, the lower series inter-spacing the upper series. Water sprays keep the boards saturated and the spaces are sprayed thus, precipitating the grit to the sludge channel below.

Both these systems give good results and also have the advantage of washing some of the sulphurous compounds from the gases, but they require abundance of water, and the disposal of the water is likely to present a difficult problem. Where water is limited and has to be recirculated, such water becomes gritty and chokes the sprays, and there is also a tendency for acid action on all piping, unless well neutralized with an alkali. A further disability is the disposal of the wet sludge or slurry, not an inconsiderable item on maintenance charges.

ELECTROSTATIC PRECIPITATION.

By this method flue gas passes through pipes or between plates known as collector electrodes, these are earthed and receive the dust from the gas. In the pipes or between the plates are wires or rods with discharge points, and these wires or rods are maintained at a high negative potential, as a result a brush discharge takes place, the wires glow and particles in the gas become ionized. The charged particles are now between the negative or discharge electrodes and the positive or collector electrodes which are connected to earth. The particles, therefore, migrate towards the collector electrodes and give up their charge. The discharged particles may fall into hoppers below or may adhere to the collector plates, a mechanical contrivance automatically raps the plates, causing the dust to slide off and fall to the hoppers for collection.

It will thus be seen that each system has its merits and demerits.

The following comparative figures are taken from page 30 in the Report to the Electricity Commissioners on The Measures which have been taken in this County and others to obviate the Emission of Soot, Ash, Grit and Gritty Particles from the Chimneys of Electric Power stations, 1932. (*see page 69*).

As regards the space occupied, it will be noticed that in floor space the "dry" plants are the more economical, but in cubic capacity they are the most extravagant. The nett result would seem to be in favour of the "dry" plants, especially where the cost of land is high.

One is often met with the statement that such and such an apparatus attains to 85%, 90% or 95% efficiency, in other words that 85%, 90% or 95% of the grit contained in the flue gases is removed. It is not my purpose to support nor to refute such a claim, neither am I interested in such a contention. My concern is not with the amount of grit arrested, but with the X% the apparatus fails to arrest, and which is emitted from the chimney to pollute the atmosphere and descend on persons and property over a large area.

Such emissions are especially noticeable during and after soot blowing, and I am of opinion it is at such times the grit nuisance occurs at its worst.

Sootblowing is usually carried out at least once during each eight-hour shift, and may last from ten to thirty minutes, depending on the size of the plant, the procedure is as follows:—

High pressure steam is injected at different points to remove the accumulated dust from the boiler tubes, etc., deposited from the flue gases on their way to the stack. During the process the normal "solid" content of the gases is considerably increased, thereby overtaxing the arresting apparatus.

At one works soot blowing was discontinued for three weeks, when it was stated that the steam production for the same coal con-

COMPARISON OF COST, ETC., BETWEEN VARIOUS TYPES OF DUST EXTRACTION PLANT.

Type of Plant.	Capital Cost.	Capital Charges (10%).	Operating Cost.	Maintenance Cost.	Draught Loss.	Total Cost per Ann.	Space Occupied (Approx.)		Draught Loss.	Outlet Temp.
							sq. ft.	cu. ft.		
Water Film (with settling tanks)	£ 3,358	£ 336	£ 123	£ 100	£ 151	£ 710	2,440	14,880	0.75	Degs. F. 120
Water Film (with filter plant)	6,308	631	442	200	151	1,424	1,480	23,190	0.75	120
Combined Water Spray and Film (with settling tanks) ...	3,540	345	123	100	201	769	3,010	25,338	1	140
Combined Water Spray and Film (with filter plant) ...	6,400	640	442	200	201	1,483	2,050	33,648	1	140
*Electrostatic ...	6,000	600	190	50	50	900	980	41,000	0.25	250
*Multi-Cyclone ...	3,420	342	75	60	395	873	900	46,200	2	250

*These figures do not allow for cost of dealing with the dust after leaving dust extraction plant hoppers. Taking the cheapest form of "wet" plant, the total annual capital and operating charges are :—

"Wet"—	
Water Film ...	£710
Combined Water Spray and Film ...	£769
"Dry"—	
Electrostatic ...	£900
Multi-Cyclone ...	£873

sumption was reduced considerably. Sootblowing at intervals of four hours slightly increased the steam output, and there was rather less evidence of grit in the immediate vicinity of the works, but I am unable to say if such a practice would result in a general improvement.

Another point of extreme importance is the fact that whilst one system may give a calculable measure of success at one plant, the same system working on an identical plant but under different conditions in another district does not give the same result. Nor is this to be wondered at when one considers the many factors involved, as for instance, the number of boilers, height of chimneys in relation to the height of the surrounding buildings, geographical position, contour of the land, etc., reserve boiler capacity, fluctuating load, ash content of the coal, available water, draught, etc., to mention but a few. In the Report of the Electricity Commissioners already referred to, there is a mine of information on the measures employed in this and other countries to overcome the emission of grit, but a careful perusal of the recommendations contained in the report leaves no shadow of doubt that much remains to be done, especially to existing plants, before it can be said that our troubles are over. It must also be borne in mind that this Report deals only with electrical undertakings, and does not include the multitude of other steam raising plants throughout the country where conditions are as bad, if not worse. Too little attention has been given to this serious problem, and certainly not as much as such a menace to health and comfort warrants. Owners of recently installed plants have endeavoured, after judicious pressure, to combat this evil, plants about to be installed will likewise be made to conform to present-day requirements if similar pressure is applied, but the older plants will continue to pour out their grit until legislation gives Local Authorities greater powers.

There is no denying the nuisance exists. Wherein lies the remedy?

At the Glasgow Conference last year a resolution was carried calling upon the Government to investigate this matter; in due course, this resolution was supported by many Local Authorities indicating the nuisance is fairly wide spread. The reply of the Minister of Health to this appeal was so nebulous that the Society has again communicated with the Ministry; we must wait and see with what result.

Finally, I would draw your attention to what I believe to be the present legal position.

Let us assume a Statutory Undertaking is causing a nuisance by emitting smoke, i.e., grit, in such quantities as to be a nuisance. The Local Authority call upon the Undertaking to take such steps as shall abate the nuisance. The Undertaking in effect can say, under certain powers conferred upon us we are bound to produce electricity, if in so doing we inevitably create a nuisance which we cannot abate by the exercise of reasonable diligence, you have no case. To use the words of Lord Justice Scrutton in the case of the "Farnworth v,

Manchester Corporation," with slight modifications—"If the defendants were to be in a better position, if they could prove that it was the inevitable result of a generating station that it should damage adjoining agricultural land (*property*) by sulphur deposits (*grit*), it was for them to prove it, and they had not satisfied him (the Lord Justice Scrutton) that they had taken all reasonable precautions to explore the causes of and remedies for that damage, or adopted all reasonable precautions to prevent it. The case showed the necessity for Parliament and other authorities concerned giving more careful attention to the provisions for compensation for damage caused by those enormous developments of electrical power stations. Promoters should not be allowed, by abstaining from asking in express words for the exclusion of any duty to make compensation for damage done—a privilege which they would not get if they had asked for it expressly—to argue afterwards that their duty to compensate had been indirectly excluded by obscure inferences." I think the position is crystallized by the dicta of Lord Dunedin in the same case, when it subsequently came before the House of Lords. After referring to the more important authorities on the law of nuisance he said:—

"I believe their whole effect may be expressed in a very few sentences. When Parliament has authorized a certain thing to be made or done in a certain place, there can be no action for nuisance caused by the making or doing of that thing if the nuisance is the inevitable result of the making or doing so authorized. The onus of proving that the result is inevitable is on those who wish to escape liability for nuisance, but the criterion of inevitability is not what is theoretically possible, but what is possible according to the state of scientific knowledge at the time, having also in view a certain common sense appreciation, which cannot be rigidly defined, of practical feasibility in view of situation and of expense."

With such a ruling before us, although in a proper case a local authority has the same redress as the plaintiff Farnworth had, its citizens must suffer to be "peppered" with grit, a sacrifice to the god, "Progress," unless they can discharge the exceptionally heavy onus of non-inevitability. As I see it, "Progress" means producing electricity as cheaply as possible—a very commendable object,—but is it to have no practical concern with damage to property, human suffering or damage to life?

There are many advocates for the removal of generating stations and other large steam raising plants to isolated spots far from all human habitation. This may be a remedy, but the economic aspect arises, and would need very serious consideration, the scrapping of these plants, the erection of new, the increased cost of fuel transport and the additional expense of lengthy distributing cables, etc., to say nothing of housing the operatives, would appear to be against such a proposal.

I prefer to believe that when engineers and scientists have given as much thought to the problem of grit prevention as they have given to cheap steam production a solution will be found.

I trust the foregoing will throw some light on the difficulties with which the sanitary or smoke inspector is confronted, and that some useful discussion will be engendered.

DISCUSSION.

Mr. B. J. Bell (British Commercial Gas Association), said he much appreciated the papers which had been read and the information that had been disseminated. Mr. Dibblin's paper did not need criticism but should be assimilated and used.

He came from a district which was dependent for its wealth on the coal industry, which was one of the biggest industries in the country, and whose product was the main cause of smoke. They must look to the coal industry for the solution of the problem. The Coal Utilisation Council and its combustion engineers had not been mentioned, but he felt that credit should be given to them.

Dr. Ruston's paper had stressed the importance of not looking at the problem from only the town's point of view. The agricultural side was also affected and was equally important.

Mr. C. M. Opie (Liverpool), asked Mr. Dibblin what types of dust arrestor would be suitable for a refuse destructor which emitted a large amount of dust and grit. 300 yards to the lee side of the destructor to which he referred was the deposit gauge which gave the country's highest readings, especially in insoluble ash.

Mr. James Law (Sheffield, Rotherham, and District Committee), said that the use of pulverized fuel was progressing rapidly and would develop to a much greater extent in the next few years. The emission of dust and grit would extend and would become a menace unless some further action could be taken. Large generating stations were in a position to put down effective grit arresting apparatus, but what about the small user who could not afford to do this? Baffles in a flue would hold about 40% of the solid matter, and this was the utmost that could be expected from small factories.

Mr. T. M. Ashford (Glasgow), said that the problem had received much attention in Glasgow. He felt that the trouble was not from the small number of large stations but from the large number of small plants. As Mr. Law had said, the difficulty was that these had not sufficient capital to instal large and costly appliances. Possibly the best for them would be the washing type.

Regarding the problem of destructors, in Glasgow there was one of the largest, in which had been installed three of the vortex type of arrestor. While they were very efficient the x per cent. which Mr. Dibblin had mentioned, was still giving trouble.

A new development which had recently come to his notice was a series of aluminium wool mats placed in the exhaust beyond the arrestors. These had proved successful. His Committee in Glasgow had recently been dealing with a large undertaking, which was capable of putting in a £10,000 installation of the static vortex type.

Councillor C. E. Keene (Leicester), said he had been asking himself what he had learned at the Conference. How could he report to his committee and make them equally enthusiastic? Would the Executive Committee be wise in carrying out more conferences in the same way? Could not the Saturday conference be made to hear only one paper or even no paper at all? He suggested the conference might be allowed to talk collectively and to discuss matters in general.

He referred to the work being done in Leicester in changing over the heating of schools from solid fuels to gas. This, he considered, would help in imbuing children with smoke abatement ideas.

Mr. John W. Beaumont (Halifax), said that he had not intended to take part in the discussion on Mr. Dibblin's paper, but would ask the Chairman to make an observation upon a point raised by Councillor Keene, re the use of gas for heating schools, hospitals, etc.

He advised Councillor Keene to visit the Civic Hall, Leeds, where he would find that all hot water required for domestic purposes and heat for warming the various rooms was obtained from gas-fired boilers which were stated to be more economical in working than a coal-burning unit, in addition to being infinitely more cleanly in use.

Mr. E. Harrold (Midlands Joint Advisory Council for Smoke Abatement), asked Mr. Dibblin which apparatus could be recommended for arresting grit from an enamelling process. A works in his district had attempted to catch grit by hoods connected with a main shoot in the roof, but he considered that a water spray should be necessary.

He suggested that the Executive Committee of the Society should collect the necessary evidence and make representations to the Government department concerned that in any new legislation there should be no industries exempted.

Many of the industries exempted under the Public Health Acts and Smoke Abatement Act could now reasonably comply with the model bye-laws, including annealing furnaces and furnaces in a number of rolling mills and iron and steel works. Also it was within his knowledge that certain brick-kilns, exempted under bye-laws, were regularly carrying on without producing black smoke.

Mr. F. J. Redstone (Bristol), said that he was astounded to hear some speakers the previous day uphold the use of one coal fire for each house. Such advocates must surely be doing this because they had failed to find an alternative fuel to raw coal which would be

quite as suitable and would be within the means as regarding price of the ordinary working man.

He said that the new gas coke grates fulfilled all the requirements of the person favouring an open fire, and that he had much sympathy with regard to the sentiments often expressed in favour of open fires. When gas coke was delivered in large lumps and attempts were made to burn it in the ordinary grates, often it was a dismal failure, but now with the excellent special grates at their disposal and with graded coke it was definitely a great success.

On speaking of smoke prevention to the housewife her first question was: how much was it going to cost her? This fuel would not involve an additional cost, but he had proved himself, as an enthusiastic user of these grates, its use would reduce the fuel bill to approximately one-half when compared with raw coal burning.

With regard to industrial smoke he thought that their greatest efforts should be to encourage the use of smokeless methods of heat production, such as gas or electricity, by the provision of special rates, and he was pleased to say that in Bristol during the past year or so hundreds of former raw coal burning furnaces had been converted to gas firing.

He could not understand why so many ardent adherents of smoke abatement continued to use the filthy and wasteful method of raw coal burning, and thought that what was required in this great and worthy movement was the "power of example"—let everyone see that they were sincere in their ideals and in this way they would undoubtedly take a great step forward towards their ultimate goal—the total abolition of all raw coal burning.

Mr. Dibblin, before replying to the discussion, elaborated his paper and stated that generally speaking the grit emitted from P.F. furnaces was incombustible matter—mostly fused silica. Other steam-raising plants, particularly those having short stacks and using too much forced draught, frequently emitted unburned carbon. The emission from a domestic grate was soot, i.e., carbon and tar, the residue of incomplete combustion due to the lower temperature attained, and this would continue until such time as smokeless fuel was obligatory or grates were constructed to effectually consume the whole of the volatiles.

As an illustration of a nuisance still arising despite an alleged 90% all-over efficiency the speaker quoted as an example a plant consuming 50 tons of coal per day, with an ash content of 10% would give out some 5 cwts. of grit. Multiply this by forty, a plant consuming 2,000 tons of coal per day with the same ash content, the emission would be 10 tons. For obvious reasons he had omitted the names of the manufacturers of the respective apparatus referred to in his paper but would be happy to furnish this information to any delegate who so desired. He also explained in greater detail his

experiments in connection with the apparatus referred to under gas washing (b).

Replying to the various speakers, Mr. Dibblin stated that the dust from refuse destructors was a serious problem, a combination in which some of the following were used: centrifugal arrestors, sprays, baffles and water traps appeared to be the best solution.

Owners of small plants invariably pleaded as an excuse the high cost of installing the necessary collecting apparatus, whereas the real reason was the inadequacy of the plant. He admitted black smoke emission was less than formerly, but that the grit problem was increasing.

It was unwise for an official of a local authority to recommend any proprietary article, firstly because he laid himself open to a charge of collusion, and secondly because should that apparatus not remedy the nuisance he ran the risk of jeopardizing any legal action.

Local authorities could assist the Society's aims for a purer atmosphere by using in their own schools, institutions, and houses smokeless fuel, gas, and electricity. Although more smokeless fuel appeared to be sold to-day, especially to the poorer classes as it was put up in small parcels, the price per ton was excessive. Gas coke, walnut size, made a good filter for arresting the pigment from enamelling process and cellulose spraying.

He had found that by fitting to boilers fire bars with $\frac{3}{4}$ " spaces, graded coke could be satisfactorily burned at less cost per lb. of steam than with coal and without smoke, whilst a domestic grate converted to burn coke could effect a saving up to 50% over raw coal.

Resolution on Exempted Processes.

Councillor W. Asbury (Sheffield, Rotherham, and District Committee), asked if it would be in order to propose a resolution dealing with the question of the withdrawal of exemptions from the Public Health (Smoke Abatement) Act of 1926. The Resolution he had drafted was as follows:—

“Resolved that this Conference of the National Smoke Abatement Society is of the opinion that the time has now arrived when serious consideration should be given to the desirability of the qualified exemption enjoyed by certain industries under the Public Health (Smoke Abatement) Act, 1926, being withdrawn.

That the Executive Committee be requested to collect and correlate information from Local Authorities on this subject with the object of making representations to the Government that in the best interests of the community such exemptions should be withdrawn.

Mr. E. Harrold (Midlands Joint Advisory Council), seconded the resolution, which upon being put to the meeting was adopted unanimously.

Dr. H. A. Des Voeux (President), proposed that the best thanks of the meeting be extended to Professor Buckmaster for presiding, and to Dr. Ruston and Mr. Dibblin for their papers. As it was the final session of the conference he wished also to propose thanks to all who had contributed to making the meetings so successful, including all the Bristol people who had so kindly helped to make the arrangements, the Lord Mayor, Mr. J. A. Robinson, the Bristol Water Company, the Gas Company, the Electrical Association for Women, and to the Society's Secretary for the arrangements in general.

Mr. Arnold Marsh (General Secretary), said he would like to take the opportunity of expressing his personal appreciation of the kindness and help given to him by their Bristol friends in arranging the Conference. It had been a pleasure to experience such courteous co-operation.

The votes of thanks were all carried with acclamation, after which the meeting closed.

LIST OF PUBLICATIONS—*continued from front cover.*

Meteorological Office, the Air Ministry. "The Effects of Smoke upon Flying Conditions" by William Courtenay. "The Effects of Smoke upon Flying in the North" by Alan Goodfellow. "Visibility and Smoke in Relation to Aerial Photography" by Captain Alfred G. Buckham, F.R.P.S. With photographic illustrations. 8vo. pp. 40. 1/-.

Smokeless Open-Grate Fuels. Report of the Symposium held in 1934. Papers and discussions on all types of solid fuels, their uses and requirements by E. K. Regan, E. W. L. Nicol, Col. W. A. Bristow, H. Cerckel, Mrs. G. H. Miles, Dr. G. E. Foxwell, John Roberts, and Dr. E. W. Smith. 8vo. pp. 60. 1/-.

The State of the Atmosphere. "An Examination into the Effects of Atmospheric Pollution on Building Stones, etc., with a Preliminary Summary of the Conditions Disclosed by various Enquiries into the State of the Atmosphere of Great Britain," by Sir Frank Baines, K.C.V.O., C.B.E., F.R.I.B.A. An invaluable survey of the subject. Royal 8vo. pp. 36. 6d.

Home Fires Without Smoke. Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. Cloth-bound remainders, 6d.

Smoke Abatement in Salt Lake City, Utah. A full and illuminating report of the intensive and successful campaign in Salt Lake City. 8vo. pp. 43. 3d.

The Smokeless Home. A popular 12-page illustrated pamphlet, with cover in colours, describing the ways and means for making the home smokeless. To be sold in quantities for general distribution. Single copies gratis. £5 per 1,000.

N.S.A.S. Annual Reports. Gratis, by Post 1d.

PROCEEDINGS OF THE ANNUAL CONFERENCES.

Each with all papers in full, and discussions. 8vo. Price 1/- each.

Newcastle, 1932. Presidential Address and papers on: "The Domestic Smoke Problem: the Possibilities of Coke-Oven Fuel"; "The Psychological Effects of Smoke"; "The Human Element: A Factor in Smoke Abatement."

Sheffield, 1933. Presidential Address and Resolutions, and papers on: "The Five-Years Clause and other Matters arising from the Public Helath (Smoke Abatement) Act, 1926"; "How the Citizen Takes the Air: The Personal Significance of the Smoke Problem"; "The Combating of Domestic Smoke in Industrial Areas."

LIST OF PUBLICATIONS—*continued*

Glasgow, 1934. Presidential Address and Resolutions, and papers on: "The Measurement of Atmospheric Pollution"; "The Effects of Smoke upon Visibility and Aviation"; "The Effects of a Smoke-Laden Atmosphere on Horticulture"; "Nature in Beautiful"; "Slum Clearance and the Smoke Problem."

Bristol, 1935. Presidential Address on "Barbarism," Resolutions, and Papers on: "The Sources of Atmospheric Pollution"; "Smokeless Equipment in Housing Schemes—Electrical, Gas, and for Solid Fuels"; "Smoke and the Countryside"; and "Dust and Grit Emission from a Sanitary Inspector's Viewpoint."

Separate Conference Papers. Reduced to 1d. each.

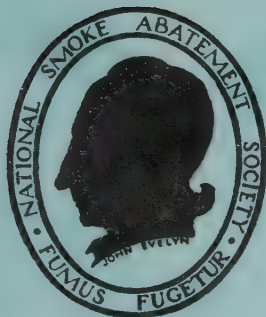
"The Progress of the Electrical Grid"; "The Production and Use of the New Smokeless Fuel 'Dryco' in Liverpool"; "Atmospheric Pollution as Affecting Visibility"/and "Visibility as Affecting Aviation"; "The Fuel of the Future" (Gas); "Powdered Fuel and the Smoke Problem"; "How Electricity Can Help in Abating Smoke"; "Power from Sources other than Coal"; "Furnace and Tank Boiler Design"; "The Smoke Inspector and the Cost of Production."

Published by Other Organizations:

"Smoke Abatement and Fuel Economy in Steam Boiler Practice" (Manchester and District Regional Smoke Abatement Committee). pp. 11. 1d., post 2d.

"The Open Fire," (Manchester Air Pollution Board). 1d., post 2d.

"The Black Smoke Tax." Report of an extensive investigation into the cost of smoke in Manchester. (Manchester Air Pollution Board). 1d., post 2d.



National Smoke Abatement Society

SEVENTH ANNUAL CONFERENCE

to be held at

BRISTOL

September 19th, 20th, 21st 1935



St. Peter's Hospital, Bristol

P R O G R A M M E

National Smoke Abatement Society



(Incorporating the Coal Smoke Abatement Society and the Smoke Abatement League of Great Britain).

President : H. A. DES VOEUX, M.D.

Chairman : CHARLES GANDY.

Hon. Treasurer : Ald. WILL MELLAND, M.A., J.P.

Hon. Advisory Secretary : Sir LAWRENCE CHUBB.

General Secretary : ARNOLD MARSH, M.Sc. Tech., M.Inst.F.

Vice-Presidents :

H.R.H. THE PRINCESS LOUISE, DUCHESS OF ARGYLL.

HIS GRACE THE DUKE OF MONTROSE.

THE RIGHT HON. THE EARL OF STAMFORD.

THE RT. REV. THE LORD BISHOP OF LONDON, P.C.,
K.C.V.O., D.D.

THE RIGHT HON. LORD NEWTON, P.C.

THE VERY REV. THE DEAN OF CANTERBURY.

SIR THOMAS BARLOW, Bart., K.C.V.O., F.R.S.

SIR OLIVER LODGE, F.R.S., D.Sc.

SIR NAPIER SHAW, Sc.D., F.R.S.

SIR ERNEST SIMON.

SIR ALEX. B. SWAN, Lord Provost of Glasgow.

PETER FYFE.

Alderman W. E. HINCKS, J.P.

DR. J. JOHNSTONE JERVIS, M.D., D.P.H.

Coun. W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.

AFFILIATED LOCAL AUTHORITIES.

Acton, Bath, Bethnal Green, Bingley, Birkenhead, Birmingham, Bootle, Brighton, Bristol, Burnley, Bury, Buxton, Cardiff, Chester, Darlington, Darwen, Doncaster, Ealing, East Retford, Edmonton, Failsworth, Farnworth, Finsbury, Greenwich, Grimsby, Hackney, Halifax, Hammersmith, Harrogate, Holborn, Horwich, Huddersfield, Irlam, Kensington, Kingston-upon-Hull, Lambeth, Leeds, Leicester, Lincoln, Liverpool, Manchester, Mansfield, Mirfield, Newcastle-upon-Tyne, Nottingham, Oldham, Poplar, Preston, Radcliffe, Richmond (Surrey), Rochdale, Royton, Salford, Sheffield Rotherham and District Committee, Smethwick, Southwark, Stalybridge, St. Helens, Stepney, Stoke-upon-Trent, Stretford, Sunderland, Swansea, Tottenham, Wakefield, Wallasey, Walsall, Warrington, Westminster, Widnes, Willesden, Wolverhampton, Wrexham, York.

Central Offices :

36 KING STREET,
MANCHESTER 2.

Office of Scottish Branch :

CITY CHAMBERS,
GLASGOW.

London Office :

71 ECCLESTON SQUARE,
WESTMINSTER, S.W.1.

ANNUAL CONFERENCES OF THE NATIONAL SMOKE ABATEMENT SOCIETY.

1929	..	Buxton
1930	..	Leicester.
1931	..	Liverpool.
1932	..	Newcastle-upon-Tyne.
1933	..	Sheffield.
1934	..	Glasgow.

PROGRAMME



THURSDAY, September 19th—

8-0 p.m. Reception by the Lord Mayor of Bristol (Alderman H. J. Maggs, J.P.) at the Mansion House, Clifton.
For particulars see "Conference Arrangements" and Reply Form.

FRIDAY, September 20th—

10-0 a.m. In the Board Room, St. Peter's Hospital, off Peter Street.

ANNUAL GENERAL MEETING

Chairman : The President.

AGENDA.

1. Presidential Address.
2. To approve the Minutes of the last Annual General Meeting.
3. To Receive the Annual Report.
4. To Receive the Annual Statement of Accounts.
5. Election of President.
Vice-Presidents.
Hon. Treasurer.
Council.
Executive Committee.
6. Any further business.

11-15 p.m. CONFERENCE. FIRST SESSION.

Chairman : Alderman J. E. Jones, J.P.

Paper by Dr. R. Lessing, Ph.D., F.C.S., etc., on
"Smoke Abatement and the Coal Industry."
Discussion.

2-30 p.m. CONFERENCE. SECOND SESSION.

Chairman : Alderman H. J. Maggs, J.P., Lord Mayor of Bristol and Chairman of the Health Committee.

Papers on

“Smokeless Equipment in Housing Schemes” :—

“Electrical Equipment,” by Geo. S. Francis.

“Gas Equipment,” by G. L. Jennings,
A.M.I.H.V.E., A.M.I.Gas E.

“Equipment for Solid Smokeless Fuels,” by
John W. Beaumont, M.R.S.I.

Discussion.

SATURDAY, September 21st—

10-0 a.m. CONFERENCE. THIRD SESSION.

Chairman : Professor George A. Buckmaster, M.D. (Oxon.), F.R.C.S., D.P.H.(Oxon.) (of Bristol University).

Paper by Dr. A. G. Ruston, B.A., D.Sc. (Lecturer and Advisory Economist, Department of Agriculture, University of Leeds), on

“The Smoke Problem and the Countryside.”

Discussion

11-15 a.m. Paper by L. H. Dibblin, F.S.I.A.,
on “Dust and Grit Emission from a Sanitary Inspector's Viewpoint.”

Discussion.

2-30 p.m. TOUR TO CHEDDAR GORGE (By kind invitation of the Bristol Water Company).

Coaches will leave the Grand Hotel at 2-30 p.m. prompt. Tea will be served at Cheddar. See “Conference Arrangements” and Reply Form.

Please Read this information carefully.

Conference Arrangements



Hotel.

The Conference Headquarters will be the Grand Hotel, Broad Street. Members and delegates in reserving their rooms should mention that they are attending the Conference, in order to obtain the special terms which have been arranged. These are:—

Bed, Bath, and Breakfast	..	..	..	..	..	9/6
Inclusive Terms, including Bed, Bath, Breakfast, Luncheon Tea and Dinner	..	..	..	..	..	14/6

Conference Fee.

A fee of 10/6 per member or delegate will be charged to defray some of the expenses of the Conference and the cost of printing the proceedings.

Reception.

Those desiring to receive an invitation to the Lord Mayor's Reception on the Thursday evening should indicate this on the accompanying Reply Form. An official card of invitation will then be enclosed with the other papers to be sent out.

Cheddar Gorge Tour.

This tour, and the tea to be provided, is by kind invitation of the Bristol Water Company. *The number is limited to 100*, and those wishing to participate should indicate this on the Reply Form, which should be returned as early as possible.

Meeting Place.

Apart from the Reception, which will be held in the Mansion House, Clifton, the meetings will be held in the Board Room of St. Peter's Hospital, off Peter Street. This room has kindly been placed at the use of the Conference by the City and County of Bristol Public Assistance Committee.

St. Peter's Hospital, which adjoins St. Peter's Church, lies close to the north side of the Floating Harbour, on the eastern boundary of the ancient city. It is a beautiful specimen of medieval architecture, and in its present form, dates from 1612. It has been used as a dwelling-house, a sugar refinery, mint, and workhouse.

Visit to New Gas Showrooms.

Members of the Conference are cordially invited by the Bristol Gas Company to take advantage of their visit to the city to inspect the new buildings and showrooms of the Company. These have only just been opened and are outstanding in their decoration,

arrangements, and extent of display. As the Conference time-table will not permit a visit on the Friday or Saturday, it has been arranged, by courtesy of the Company, to inspect the Showrooms on Sunday morning, September 22nd. Those wishing to take part are requested to meet outside the Showrooms, Colston Street, at 11-0 a.m., on that day.

All-Electric House.

An enterprise of interest to members of the Conference is being carried out by the Bristol Branch of the Electrical Association for Women, who for demonstration purposes are having an all-electric house built and equipped. It is hoped that this will be sufficiently completed by the date of the conference to make possible inspections by members of the Conference ; and a kind invitation to do this has provisionally been made by the Branch. It is expected that it will be possible to include further particulars in the final information to be sent immediately before the Conference to those who have signified their intention of attending.

Guide to Bristol.

Copies of a descriptive guide to Bristol, with map, places of interest, etc., will be forwarded to delegates and members attending immediately before the Conference.

Papers.

Copies of the papers to be read, Annual Report, Guide, and Reception, Invitation, etc., will be forwarded a few days before the Conference to all from whom the Reply Form is received by September 13th.

Date for Reply.

The arrangements will be facilitated if all those attending the Conference will return the accompanying Reply Form as soon as possible, and in any case *not later than Friday, September 13th.*

Resolutions.

Resolutions for submission to the Annual General Meeting may be sent in by members and representatives of affiliated associations and local authorities, but must be received *not later than September 6th.* Copies will then be sent out with the other papers.

Contributions to Discussions.

Members of the Conference taking part in the discussions are requested to hand a copy of their remarks to the Secretary at the time, or to forward them to him as soon as possible afterwards, in order that they may be included in the *Proceedings* of the Conference.

Proceedings of the Conference.

The **Proceedings** to be published in November, will contain papers and discussions in full. A copy will be sent without charge to each person attending the Conference, and further copies will be obtainable at a rate of 1/- each, or in quantities at 9/- per dozen.

Literature and Exhibits.

Copies of the Society's publications will be displayed and may be purchased during the Conference. A selection of exhibition will also be displayed.

Further Information.

Any further information may be obtained upon request from the Secretary, National Smoke Abatement Society, 36, King Street, Manchester, 2, up to September 18th, and afterwards at the Conference Office, Smoke Abatement Conference, Grand Hotel, Bristol.

36 KING STREET,
MANCHESTER, 2.
BLACKfriars 0896.

ARNOLD MARSH,
General Secretary.

CONFERENCE NOTES

AI

NATIONAL SMOKE

ABATEMENT & PREVENTION

THE SOURCES OF ATMOSPHERIC POLLUTION

by

Dr. R. LESSING, Ph.D., F.I.C., M.I.Chem.E., F.Inst.F.

A paper read at the Annual Conference of the National Smoke Abatement Society held at Bristol, September 20th and 21st, 1935 and reprinted from the "Proceedings of the Conference".

THE SOURCES OF ATMOSPHERIC POLLUTION.

By Dr. R. LESSING, Ph.D., F.I.C., M.I.Chem.E., F.Inst.F.

Chairman: Alderman J. E. JONES, J.P.

It is perhaps not without significance that the coal smoke abatement movement owes its organized existence to an artist. Sir William Richmond, the founder of the original society, opened the campaign against what he could perceive with his eye, the sooty emission from chimneys. The early activities of the Coal Smoke Abatement Society, which together with the Smoke Abatement League of Great Britain is now merged in the National Society, were mainly concerned with visible smoke and its observation by inspectors for statutory periods with a view to setting the existing law in motion against incorrigible offenders, and with obtaining new and more effective legislation for the abatement of the evil. The establishment of proof of the obnoxious effects of coal smoke suffered from the inherent difficulty of proving a truism.

The need for methodically collecting information of tangible pollution throughout the country and analysing the data obtained by scientifically sound methods, led to the formation in 1912 of the Atmospheric Pollution Committee. This Committee was conducted originally on a voluntary basis by a few enthusiasts under the chairmanship of Sir Napier Shaw and later was taken over by the Air Ministry and the Department of Scientific and Industrial Research. The Reports of this Committee, of which the 20th was published this year, form a valuable record of the incidence of a limited number of polluting substances mainly derived from the combustion of fuel, and their topographical and seasonal distribution over a large and representative number of localities throughout Great Britain. Within their closely limited scope the data collected in 20 years form probably the most complete and continuous record of atmospheric pollution in any country.

The observations, valuable as they are, were never intended to show more than the general effect of chimney emission on the purity of the atmosphere. The principal method of ascertainment, the collection of solids from the atmosphere by spontaneous settlement and washing out with rain water, was not intended to prove, except by inference, the deleterious effect of the polluting substances on buildings, metals, textile fabrics or on the human and animal body. In the light of future research it should be possible to extract more information from this statistical evidence than could be obtained from the individual observations as and when they were collected.

Whilst the methodical work done during the last 20 years was intended to ascertain the amount and composition of the smoky pollu-

tion in the atmosphere, no systematic investigation of the effect of smoke has been made. A great deal has been written on the general qualitative damage caused by atmospheric pollution and attempts have been made on many occasions to assess this damage in monetary value, a most difficult if not impossible task in view of the insidious nature and of the multiplicity of factors involved. Efforts to abate the smoke nuisance have been mainly directed to the employment of "smokeless" heating agents, gas, coke, semi-coke, anthracite and electricity. As far as the abolition of visible smoke is concerned any of these would of course provide a complete cure. Methods of combustion of fuel liable to produce smoke have not been investigated adequately for the specific purpose of smoke prevention, nor have the results of trustworthy researches been popularized to a sufficient degree. Attempts to educate stokers of boiler plants and firemen of industrial furnaces have been spasmodic, and much more could be done by the more general institution of classes by local authorities and trade associations, possibly in collaboration with technical schools and colleges.

Furnace equipment and operating methods, particularly of large scale boiler and other heating installations, have been developed and improved to a remarkable extent of recent years. Whilst the object has been primarily one of a more economical utilization of coal and saving of labour, success in these attempts has generally had the effect of reducing or eliminating smoke emission. Little or nothing has been done in improving the combustion conditions of domestic coal fires and cooking ranges in the vast majority of existing dwellings throughout the country beyond the fitting of more up-to-date fire-places and in the case of new houses, the fitting of a variety of "smoke-reducers" of somewhat doubtful value.

The time has come when stock should be taken of the conditions of chimney emissions as we find them to-day and the problem should be restated in the light of the fundamental sources of atmospheric pollution. When this is done it will be found that the pollution consists of more than mere smoke and that agencies causing widespread nuisance and injury comprise factors other than visible smoke. One may even go so far as to say that the chief direct damage by chimney emissions is not due to their carbonaceous content, but is due mainly to the acid constituents of the products of combustion.

This does not mean that the visible components of smoke consisting of carbon and tarry matter are not of vital importance, for apart from their action in tarnishing metals, soiling textile fabrics, buildings and the human body both externally and in its respiratory system, they deprive us of sunlight and thereby are injurious to physical health and, by creating a depressing environment, affect our mental well-being.

Moreover, the obstruction by smoke clouds of the highways of aerial traffic is a danger to aircraft and thus impedes the natural progress of this rapidly increasing mode of transport, a fact most

forcibly demonstrated by the recent discussion on the subject before this Society.

In yet another direction the problem to-day differs from that at the beginning of the century by reason of the concentration of factories and public utility undertakings into larger units and, apart from the steady increase in the number of gas fires and electric heaters, by the installation of central heating in the rapidly increasing number of blocks of flats and offices, hotels, hospitals and institutions.

COMPONENTS OF CHIMNEY EMISSIONS.

In order to appreciate these developments it will be useful to examine the sources of chimney emission in greater detail and it will be convenient to do this under the three main heads of smoke, acid gases and dust.

SMOKE.

In order to consider the production of smoke, the behaviour of various fuels during combustion must be studied. Combustion is by no means as simple a process as might appear from the final products of the combination of oxygen with carbon and hydrogen. If we consider the combustion of even the simplest hydrocarbon we find that the reaction of oxygen with carbon and hydrogen passes through a number of intermediate stages before the final products, carbon dioxide (CO_2) and water (H_2O) are formed. The intermediate products may differ according to the conditions of combustion, which may range from slow combustion to explosion depending upon the proportion of oxygen present, homogeneity of mixture, temperature and pressure. Many theories have been advanced, such as the preferential combustion of hydrogen, the formation of peroxides, and the formation of aldehydes according to the hydroxylation theory. Some of these theories are still under discussion, and if the combustion of the simplest type of hydrocarbon, such as methane, presents these theoretical difficulties, how much more complicated are the conditions of combustion of the complex hydrocarbons, such as the so-called illuminants in coal gas, or the constituents of ordinary motor spirit.

Provided a sufficient excess of oxygen is available during the combustion of hydrogen, or of combustible gases such as carbon monoxide and simple hydrocarbons, the combustion is relatively complete, and the products are entirely free from smoke. Coal gas and producer gas must therefore be regarded as prototypes of smokeless fuels.

Liquid fuels are in some respects similar to gaseous fuels. As they are richer in carbon and free from non-combustible constituents, they require a greater amount of oxygen. In order to allow this oxygen to act quickly enough, the mixture must either be burned under pressure or, as in the case of heavy fuel oils, the temperature of the flame must be kept well above the ignition point of the fuel so as to ensure rapid and complete combustion. If this is not the case, as

during the lighting-up period of an oil-fired furnace, smoke may be produced even though an adequate excess of oxygen is present.

If we come to consider the combustion of solid fuel it will be simplest to begin with coke. Coke is made by the thermal decomposition at temperatures above 900°C of coal, whereby the volatile constituents or decomposition products, gas, tar and water are removed, the last named containing the ammonia liberated. If an ideal coke could be produced, i.e., one free from ash and other impurities and from which every trace of volatile matter had been removed, the material would have the chemical composition of pure carbon. When burned in oxygen pure carbon dioxide would be produced or, if burned in air, the carbon dioxide would be diluted by nitrogen and the excess of oxygen. In practice such an ideal fuel cannot be commercially produced and coke therefore contains varying amounts of ash, sulphur and residual volatile matter. In order to effect combustion, that is to say, to allow the oxygen to combine with the carbon, it is necessary to raise the coke to its ignition point which ranges approximately from 500° to 600°C . When this temperature is reached on the surface of a lump of coke, combination of oxygen with the carbon begins and a small portion of the heat thus engendered raises succeeding layers to and above the ignition temperature so that combustion can proceed continuously. The ignition point depends on the physical structure of the coke itself and to a certain extent on the volatile combustible matter left in it after carbonization. Whilst this volatile matter aids the ignitibility of the coke, it is so small in amount and of such a character that under normal conditions it does not produce any smoke. For practical and particularly for domestic purposes it is important to bear in mind the difference between ignitibility and combustibility of a fuel. Coke is undoubtedly less readily ignitable than, say coal, but—and this is an important point in starting a fire—once the ignition point has been reached by means of paper, wood or a gas poker, its rate of combustion will normally be adequate for maintaining a continuous fire.

For practical purposes it may be taken that direct combination of oxygen with solid carbon takes place; hence the flame produced by a coke fire is more concentrated and shorter than that of a coal fire. Its heating effect, therefore, depends mainly on radiation from the solid, incandescent pieces of coke. Moreover, as combustion is rapidly brought to completion, the flame is colourless or bluish and does not present the yellow appearance of the flame from coal due to partially burnt or cracked tarry matter.

The bulk of the coke used for domestic purposes is derived from gasworks. During the recent depression in the iron and steel trade metallurgical coke made in coke ovens has found its way into the domestic market. This coke owing to its preparation in greater bulk, at somewhat higher temperature and from more compact coal charges, is denser than gas coke and somewhat less readily ignitable. On the

other hand, it is claimed for oven coke that being generally made from washed coals it contains less ash than gas coke. Both varieties comply with the most stringent demands for smokelessness.

Exactly thirty years ago the late Thomas Parker proposed the carbonization of coal at a lower temperature than is usual in gasworks and coke ovens, for the production of semi-coke to which he gave the name Coalite. This was intended to supply a solid domestic fuel more readily ignitable than coke, but free from that portion of the volatile matter in coal which would be liable to smoke formation. This is not the place to describe the vicissitudes of low temperature carbonization. If this process from the beginning had been developed on the basis of scientific and technical research and with due regard to its economic limitations, instead of being invested with mysterious and exaggerated potentialities and being made the plaything of unscrupulous financiers and a popular counter of the gambling public, this process might to-day occupy an important position in the industrial structure of the country. As it is, the production of semi-coke is only small as compared with the total fuel consumption of the country, but it is large enough to form a useful measure of its popularity with those who are in the habit of using this fuel. The economics of the process have been discussed *ad nauseam* on many occasions and from many angles, with pros and cons by the promoters of low temperature carbonizing companies and by opposing interests. In years to come it will probably be found that with the goodwill of all parties concerned the industry can be carried on with a normal moderate trading profit and will fulfil a useful purpose.

What matters from the point of view of to-day's discussion is that the fuel produced, provided it is made from low-ash coals and is of reasonable density and sufficient strength to resist breakage during transport and handling, should be welcomed as a smokeless domestic heating agent in addition to and not necessarily in substitution of, coke, anthracite, gas and electricity.

When dealing with the subject of coal from the point of view of smoke production the anthracite variety must be considered in a class apart. Anthracite occupies the highest place in the range of the coalification of plant materials. In researches on the formation of coal we are now accustomed to speak of its "rank," the "rank" rising from peat as the lowest member through brown coal and the various stages of bituminous coal to anthracite. It may be appropriate to recall that at this year's meeting of the British Association some time was devoted to a discussion on the "rank" in coal. The rise in rank of coal is brought about by the elimination of certain portions of volatile matter, with the result that in the highest member of the series, anthracite, only a minimum of volatile matter is left in the material. Anthracite may therefore be regarded as the product of a natural low temperature carbonization, carried on during geological periods at temperatures which are not likely to have exceeded 200°C. It is obvious that the

final product presents an entirely smokeless fuel and it is due to this and to the fact that, for reasons as yet not adequately explained, anthracite contains a very small percentage of ash, that this fuel occupies the premier position in regard to market price.

Coming now to the consideration of bituminous coal, the question arises how smoke is formed from it. Bituminous coal is fired in sizes ranging from lumps in the case of domestic fires down to small slack sizes on mechanical stokers. Combustion, whatever its intricate mechanism may be, proceeds mainly if not entirely on the surface of the particles or lumps. The heat liberated by the combination of the surface layers with oxygen progressively raises the temperature of adjacent layers, and eventually the interior of the whole mass is heated to a temperature approaching that of the outside. It thereby causes thermal decomposition to take place, very much on the lines of carbonization in a gas retort or coke oven in the absence of oxygen. While the outside of a piece of coal is burning, the interior is converted into coke, the volatile matter coming into contact with the combustion air only after it has left the solid particle in which it had been confined. As combustion does not take place instantaneously, and as the gases and vapours under normal draught conditions are quickly removed from within the fuel bed, they leave the bed in form of a flame the length of which varies with the coal employed. Being no longer in direct contact with the hot surfaces of the incandescent fuel bed, their temperature is lowered and a portion of the tarry vapours will therefore escape unburned or partially burned, whilst other portions are cracked to carbon which escapes as soot. In this manner the products of combustion are emitted from the chimney laden with smoke.

The progressive coke formation from coal on a chain grate stoker was studied by J. B. Maughan (Grumell, J.Inst.Fuel 1932, 5, 361) who found that "green" coal was completely coked after the fuel had travelled along one-half of a grate 10 feet long. What happened at different points of a travelling grate, will occur at different periods of time on a stationary grate. Whilst even during the coking period a certain amount of combustion takes place, this experiment shows clearly the sub-division of the burning of bituminous coal into carbonizing and combustion periods.

In properly designed industrial furnaces, such as an ordinary boiler furnace, the gases released from the fuel bed pass along an arch of refractory material which is maintained at high temperature. By contact with the hot firebrick and by radiation from it, the gases leaving the fuel bed unburned or incompletely burned, are kept at the requisite temperature, so that by allowing secondary air to be mixed with them, their combustion is completed. They will therefore escape without carrying any smoke with them.

In the domestic fireplace a furnace arch properly shaped for confining the gases is not provided. Considerable cooling therefore takes place above the fuel bed and unburnt tarry vapours remain in the

chimney gases without being subjected to secondary combustion. While sufficient air is present for supplying all the oxygen, both primary and secondary, required for total combustion, the cooling effect is usually too great to permit this. In fact the construction of the ordinary fireplace and particularly the old-fashioned one, is such that far too great an excess of air passes up the chimney, which in itself causes the gases to be unduly cooled. Whilst this large excess of air has a most wholesome ventilating effect, it is detrimental to the reduction or entire elimination of smoke. It is for this reason that domestic fires using bituminous coal are such prolific smoke producers and that the soot formed by them contains relatively high proportions of tarry matter. On the other hand, there is no reason why smoke should be emitted from steam boilers and other industrial furnaces if operated in a competent and workmanlike manner.

There is one form of industrial firing of bituminous coal which merits special consideration, the combustion of coal in pulverized form. By reducing coal in grinding mills to dust form so that the bulk of it, say 80%, will pass through a sieve of 200 mesh to the linear inch, and by blowing this powdered fuel suspended in the combustion air into furnaces, the mechanism of combustion is modified from that applied to coal in massive form. The particles are so small that a very intimate mixture of coal and oxygen is obtained, and the time required to burn each particle from its outer surface to its centre, is reduced to a minimum. The ratio of air to fuel can therefore be adjusted very closely and high combustion efficiencies are obtained which compare well with those of atomized fuel oil and approach even those of gaseous fuels. Since on account of the smallness of the particles the carbonizing and combustion phases practically overlap, and in view of the intimate mixture with the air, this system of firing is not likely to allow smoke, as distinct from coke and ash particles, to be emitted from the chimney.

ACID GASES.

Until a few years ago smoke was considered the principal contributor to "atmospheric pollution." It was known and realized that the sulphur contained in all fuels gave rise to the formation of acids which caused severe corrosion in everything with which they came in contact, in particular building materials, metals and textiles. The quantitative effect of these impurities has, however, not been realized and is perhaps even to-day not sufficiently appreciated.

In a paper submitted to the second World Power Conference 1930, I discussed these quantitative relations and compared the chimney emissions in respect of ash, dust and sulphur oxides as derived from ordinary coal and from coal which has been cleaned by the elimination of the natural coal dust and all removable impurities so that it contains only inherent ash and sulphur. The following table, calculated on a conservative basis, illustrates these conditions in respect of sulphur.

When applied to the case of a modern power station burning 2,000 tons of coal per day, figures are obtained which show the immense damage which would be caused, if no steps were taken, firstly for removing the bulk of the offending impurities from the coal

TABLE I.—SULPHUR DATA.

	A. Uncleaned coal.			B. Clean coal and dust mixed.	C. Clean coal.	
Sulphur in coal	3·0	2·0	1·0	0·77	0·75	Per cent
Gross calorific value	5,940	5,940	5,940	7,170	7,250	kcal/kg
RELATED TO 1 TON OF UNCLEARED COAL.						
Coal required	1·000	1·000	1·000	0·784	0·770	Tons
Sulphur in coal	0·030	0·020	0·010	0·006	0·006	„
Sulphur dioxide in combustion cases	0·060	0·040	0·020	0·012	0·012	„
Sulphur trioxide equivalent CaCO_3 required to neutralise SO_2	0·075	0·050	0·025	0·015	0·014	„
River water (containing 20 parts of CaCO_3 per 100,000 parts) required to neutralise SO_2	0·094	0·062	0·031	0·019	0·018	„
CaSO_4 formed	469	312	156	94	90	„
Water required to dissolve CaSO_4	0·127	0·085	0·043	0·026	0·025	„
	64·0	42·5	21·3	12·8	12·3	„
RELATED TO 2,000 TONS OF UNCLEARED COAL.						
Coal required	2,000	2,000	2,000	1,570	1,540	„
Sulphur in coal	60	40	20	12	11·5	„
Sulphur dioxide in combustion cases	120	80	40	24	23	„
Sulphur trioxide equivalent CaCO_3 required to neutralise SO_2	150	100	50	30	29	„
River water (containing 20 parts of CaCO_3 per 100,000 parts) required to neutralise SO_2	187	125	63	38	36	„
CaSO_4 formed	937,000	625,000	312,000	189,000	180,000	„
Water required to dissolve CaSO_4	254	170	86	52	50	„
	127,000	85,000	43,000	26,000	25,000	„

before burning, and secondly for extracting the residual portion from the flue gases before they are allowed to escape into the atmosphere. In such a case, practically the whole sulphur in the coal with the exception of a small portion retained by the furnace brick-work, and, according to the method of firing, varying portions of ash, dust or grit would be discharged from the chimneys.

As an example of sulphur emission the case of Greater London may be cited. In 1934 19,282,000 tons of coal and coke were brought into London and with minor exceptions, such as gas coke exported, were consumed in London. Of this total 6,282,000 tons came by rail, 43,000 tons by canal and 12,957,000 tons were sea-borne. The rail-borne coal may be regarded as mainly domestic and the water-borne as mainly industrial. Assuming the sulphur content of this coal to be 1 per cent., which must be regarded as a minimum, we find that a total of nearly 500,000 tons of sulphur, expressed as sulphuric acid, is discharged into the atmosphere from the 700 square miles of Greater London, industrial uses being responsible for about two-thirds and domestic consumption for one-third of the total. At the lower temperature of the domestic grate a little sulphur is probably retained by the ash which may call for a slight adjustment. An adjustment of this figure must also be made in respect of the sulphur removed in the purification of coal gas, amounting to about 55,000 tons per annum, and in respect of the sulphur contained in gas coke exported from London, which accounts for about 12,500 tons in terms of sulphuric acid. When the two large power stations at Battersea and Fulham, in which the sulphur is removed from the flue gases, are completed, a further reduction of the total by nearly 40,000 tons per annum in terms of sulphuric acid is to be expected.

It is gratifying to see that these industries in which positive sulphur removal is practised, are instrumental in reducing the total sulphur emission over London by about 20%. The balance of about 400,000 tons per annum of sulphuric acid still means the daily liberation of over 1,000 tons of the sulphuric acid equivalent of sulphur into the atmosphere of London, and it is safe to assume that with the true sulphur content in the coal actually burned this figure may have to be increased by nearly 50%.

It is interesting to compare this huge total with the sulphur oxides retained in the pollution gauges. A rough approximation of the SO_3 in the mean deposit in London shows an annual total of 25,000 tons, or only one-sixteenth of the original emission. It would be an interesting problem for the Atmospheric Pollution Committee to inquire into the final disposal of the balance unaccounted for. The major portion is probably carried away with the wind, but another appreciable portion is retained by way of corrosion and of disintegration of building materials.

A consideration of these quantitative data gives a plausible explanation of the destructive effect of chimney gases on stone, metals, textile fabrics and other materials which has manifested itself so widely, and in particular in such glaring instances as the decay of the masonry of the Houses of Parliament and other public buildings, to which attention has been directed so forcibly by the late Sir Frank Baines.

In dealing with the acid constituents in flue gases reference is not frequently made to the oxides of nitrogen. These are formed

in modern high temperature combustion processes to quite an appreciable extent and their contribution to atmospheric pollution must not be underestimated.

The presence of acids in chimney emission has only recently become an acute problem. After the claims of the aggrieved owner of land damaged by sulphur gases from the Barton Electricity Works of the Manchester Corporation were sustained by a judgment of the House of Lords in 1929, the Electricity Commissioners insisted that at the new London power stations to be erected at Battersea and Fulham, the necessary steps should be taken to eliminate practically all the sulphur oxides from the combustion gases of their boilers before discharge to the atmosphere.

It is a remarkable testimony to the power of public opinion that the outcry against the erection of two large power stations in the heart of the metropolis caused work to be undertaken which brought within the short span of five years a problem, then practically non-existent, from a state of almost complete ignorance on the subject-matter to its virtual solution.

The work done on independent lines by the London Power Company, by the engineers and technical advisers of the Metropolitan Borough of Fulham and by Imperial Chemical Industries Limited jointly with James Howden & Co. Ltd., must be regarded as technical achievements of a high order, considering that the standard set by the supervising authorities demands the extraction of 98% of the sulphur dioxide present in the flue gases in as low a concentration as 0.07% by volume, and that the volume to be treated in one station when fully equipped is 1,500,000 cubic feet per minute.

It should also be noted that in this field Great Britain has been leading, and in no other country have plants of similar dimensions yet been installed. Moreover, the process adopted at Fulham, although it employs wet washing, provides for the continuous recirculation of the scrubbing liquid without necessitating the discharge of a noxious effluent into the River Thames. The prevention of the escape of sulphur oxides into the atmosphere is therefore not effected at the expense of the purity of the river water. In order to make this possible and at the same time avoid the incrustation of the scrubbing plant with solid deposits, new ground had to be broken in elaborating the chemical reactions involved and in applying them on a very large scale.

DUST AND GRIT.

At one time so little attention was paid to the nuisance created by the emission of ash-dust from the chimneys of large power units that in a discussion before the Institution of Electrical Engineers in 1923 on a paper introducing powdered fuel into this country, I uttered a warning against the replacement of the vanishing smoke nuisance by a steadily growing dust menace. I discussed this matter in detail in the above-mentioned paper before the World Power Conference in

1930, and the following table shows the conditions of flue dust emission from boiler furnaces, for powdered fuel firing and mechanical stoking.

TABLE II.
EFFECT OF COAL CLEANING ON QUANTITY OF FLUE DUST EMISSION.
(Without flue dust catchers).

	A. Un- cleaned coal.	B. Clean coal and dust mixed.	C. Clean coal.	
POWDERED FUEL FIRING.				
Total ash	14·00	3·78	2·64	Per cent. of coal
Flue dust emitted	80	10	10	Per cent. of ash
Flue dust emitted	11·20	0·38	0·26	Per cent. of coal
Equivalent weight of coal ...	1·00	0·80	0·79	Tons
Flue dust emitted related to equivalents of 2,000 tons of coal A	224	6·1	4·1	„
MECHANICAL STOKING.				
Flue dust emitted	1·67	1·60	0·60	Per cent. of coal
Combustible in flue dust	70	73	80	Per cent. of flue dust
Equivalent weight of coal ...	1·00	0·78	0·77	Tons
Flue dust emitted related to equivalents of 2,000 tons of coal A	33·4	24·3	8·9	„

I then inquired into the behaviour of the various constituents of coal ash from the coal bunker to the chimney top and compared the potential dust emission from raw and clean coal. As in the case of sulphur, the totals were calculated for stations burning 2,000 tons of coal per day, and it will be noted that the improvements obtainable by coal cleaning are even more remarkable than in the case of sulphur.

A number of dust catchers have been introduced, employing either dry or wet operation. In one type of dry dust catchers cyclones are employed in which the dust is eliminated by centrifugal action; whilst these are quite efficient in removing the major portion of the coarse dust, they are usually not capable of catching the finest grades of dust. Another type employs electrostatic precipitation. This is of high efficiency although correspondingly expensive in installation and operating costs. The wet scrubbing system has the advantage, if properly designed and operated, that it can deal simultaneously with dust and sulphur oxides. In the case of Fulham, for instance, a 98% sulphur extraction efficiency involves a practically complete removal of all dust without any special provision in the plant.

A Committee appointed by the Electricity Commissioners to consider and report upon the measures which have been taken both in this

country and in others to obviate the emission of soot, ash, grit and gritty particles from the chimneys of electric power stations, made a careful inquiry into this problem and issued a report in 1932. A Committee of the British Standards Institution is now engaged in working out a standard specification for testing the concentration of flue dust in chimney gases and the efficiency of dust extraction plant.

The problem is therefore receiving attention, but what remains to be done is to spread the knowledge of the possibility of abating the nuisance and to take steps in applying this knowledge by making provisions for the installation of efficient cleaning plant a standard equipment of boilers and industrial furnaces generally.

It is to be hoped that the action of the Council of the Society in submitting to the Minister of Health the resolution in regard to dust and grit emission passed at the Glasgow Conference in 1934 and in calling attention to such nuisance arising from smaller plants other than generating stations and statutory undertakings, will have the desired effect of providing local authorities with expert technical advice.

The flue dust nuisance is by no means restricted to industrial furnaces proper. There is a rapidly increasing danger of a serious addition to atmospheric pollution by dust from the boilers installed for central heating and hot water supply in the rapidly increasing number of flats, offices, hotels, hospitals and institutions already referred to. In the individual dwelling house with its multiplicity of separate chimneys for each fireplace, reasonably low flue gas velocities are employed and consequently dust emission is restricted. In the larger buildings, each serving a small community of people, the heating services are centralized, and in consequence assume quite appreciable proportions. The flue gas velocities, therefore, become so high, particularly where forced draught is employed, that there is a risk of dust and grit being ejected, which owing to the usual situation in densely populated and high class residential districts, gives frequently rise to particularly objectionable nuisances.

REMEDIES.

The foregoing considerations may be summarized with a view to their practical significance in the following paragraphs :

(1) Smoke containing tarry matter is produced mainly from domestic coal fires. The obvious remedy is to substitute smokeless heating agents, anthracite, coke, semi-coke, gas, electricity, for raw coal in the open grate and kitchen range. This may be a counsel of perfection, seeing that the quantity of domestic coal consumed in this country is from 35,000,000 to 40,000,000 tons per annum, at which figure it has remained stationary for many years. This tonnage represents about one-quarter of the total consumption, and the capital expenditure required for the production of its equivalent of smokeless heating agencies is larger than the nation would willingly face in a short

period of time. Moreover, house coal commands the highest market price of all grades of coal and it is the obvious tendency of the coal producer to retain the market for this highly-priced portion of his output, to make up the deficiency caused by selling other grades below the average cost of production. Much as one would like to see it, the abolition of the use of raw coal for domestic purposes by the stroke of the pen is not within practical politics.

What should, however, be feasible is the improvement of the customary and highly inefficient method of managing the domestic fire. It should be possible to devise appliances and methods by which the eventual discharge of smoke into the chimney can be prevented without interfering with the brightness of the fire. It is satisfactory to note that the Coal Utilisation Council is contributing funds for an investigation of the subject by the Fuel Research Board.

(2) Smoke containing little or no tarry matter is emitted from industrial furnaces fired with coal or oil only in those cases where either the design or the operation is faulty. Improvement in this direction must be effected mainly by technical instruction of those directly and indirectly responsible.

(3) Acids, and in particular sulphur oxides, are formed in the combustion of all classes of fuel. An important reduction in the sulphur discharged is effected by coal cleaning, as shown in Table I. As the organic sulphur in coal cannot be removed in the cleaning process, the formation of some sulphur oxides from coal or coke cannot be avoided. Means are now available for economically eliminating the injurious compounds from flue gases, and if these are adopted wherever the size of installation permits, a very appreciable reduction in corrosive pollution will take place. As the two power stations at Battersea and Fulham will eventually account for a reduction of the sulphur emission over London by 10%, one may expect a very considerable improvement in respect of acid gases in a reasonably short time by multiplying the installation of similar plant.

(4) Dust and grit are liable to be emitted from all solid fuels in accordance with the physical laws governing the relation between size of particles and velocity of the gases carrying them. The remedies for this nuisance are practically the same as those for sulphur removal. By cleaning the coal prior to use, the ash of which flue dust mainly consists can be reduced as shown in Table II. With intensively washed coals, the flue dust evil practically disappears. I have shown in the paper previously referred to and in one on "Clean Coal in the Gas Industry" submitted to the Institution of Gas Engineers in 1931 that savings can be effected amounting to over 1/- per ton of boiler coal and over 2/- per ton of gas coal after allowing for the total cleaning expenditure.

The flue dust derived from the residual ash in coal and mostly also comprising some carbon particles, possibly in form of cenospheres, can be dealt with by dust catchers and scrubbers of varying efficiency.

SURVEY OF SOURCES OF ATMOSPHERIC POLLUTION.

Whatever expenditure is incurred in preventing or reducing the pollution of air from the various sources, must be offset against the damage caused by its insidious action. Sufficiently detailed and trustworthy statistical data for estimating it are not available, but it is certain that the damage suffered by the community amounts to a very large total and probably to not less than £1 per annum per head of the urban population. The time has come when this serious matter should receive more active consideration than has been given to it in the past. I suggest that the question of instituting a survey of the contributory causes of atmospheric pollution should be studied, with a view to preparing the ground and formulating methods by which such a survey could be carried out. The results obtained by the Atmospheric Pollution Committee during its 20 years' activities might form a starting point. Although its observations relate to only a relatively small phase of the problem, it should be possible to extract from them general indications of the sources of polluting matter discharged into the atmosphere beyond the portion actually collected.

In the first instance representative groups of the various types of chimney emission ranging from the small domestic fire to the largest power station boiler should be examined and the chemical composition and the physical condition of the gases should be ascertained.

An estimate of the distribution of coal in Great Britain in 1934 amongst the various classes of consumers is given in the following table.

TABLE III.—CONSUMPTION OF COAL IN GREAT BRITAIN IN 1934.

Consumer.	Quantity (Million Tons).	Percentage Proportion of Total.
1. Gas Works (excluding the coal equivalent of gas coke exported)	16·66	10·3
2. Electricity Generating Stations belonging to authorised undertakings and to railway and tramway authorities	11·17	6·9
3. Railway Companies (for locomotive use).....	12·17	7·5
4. Vessels engaged in the Coastwise Trade (bunkers)	1·26	0·8
5. Iron Works (used in Blast Furnaces)	10·40	6·5
6. Other Iron Works and Steel Works	6·81	4·2
7. Collieries (engine fuel)	11·68	7·2
8. General Manufactures and all other purposes (including Domestic use)	91·33	56·6
Total	161·48	100·0

The sources of chimney emission in a number of these groups are sufficiently uniform in themselves that fairly reliable conclusions can be drawn from the examination of relatively few examples. The greatest difficulty will be presented by Group 8, which is the largest and in which the great variety of general manufactures and all domestic fuels are lumped together. The planning of an inquiry into this group will therefore have to be done on the basis of a competent and very critical examination of the material already available.

It is hoped that the present paper might, after the elaboration of its general outlines in sufficient detail, form a skeleton on which a plan for a complete survey of atmospheric pollution could be based.

DISCUSSION.

Alderman J. E. Jones, the Chairman, in introducing Dr. Lessing prior to the presentation of the paper, said that he was glad to be able to welcome the conference to the ancient city of Bristol, one of the finest cities in the world. In declaring the meeting open for discussion after Dr. Lessing had spoken, Alderman Jones spoke briefly of the smoke nuisance as it concerned Bristol.

Mr. E. W. L. Nicol (London and Counties Coke Association), said that in his very excellent paper Dr. Lessing had laid much stress on the sulphur content of coke. He pointed out that in the carbonization of coal at gasworks the volatile sulphur was driven off and was collected as a bye-product. It followed, therefore, that the volatile sulphur content of coke was less than that of coal.

Councillor C. E. Keene (Leicester), referred to the point raised by Dr. Lessing in his paper regarding the installation of central heating for flats, offices, hotels, hospitals and institutions. In his opinion coal-fired central heating appliances were largely responsible for the sulphur nuisance. Was there not another method instead of coal for such heating? In his own factory he used forced gas.

Anthracite, he said, was very good, and he would like to see more of it in use, but its price was prohibitive.

Councillor F. Totterdill (Portishead), referred to the Power Station of the Bristol Corporation erected at Portishead, upon land purchased by the Corporation, and the effects it had on the village.

He thought it essential that the Corporation should enforce its bye-laws, and see that they were properly carried out, even with respect to its own undertakings.

Mr. L. H. Dibblin (Willesden), referred to the suggestion made by Dr. Lessing that all coals should be cleaned before using, and that this did not add to the cost. He wished to know if this could also be applied to domestic coals, and especially how could the cleaning be done without cost?

Alderman J. H. Waddington (Halifax), referred to the statement made by Dr. Lessing that "the abolition of the use of raw coal for domestic purposes by the stroke of the pen is not within practical politics."

In most of the northern towns and cities the municipalities provided the public services. Gas, water and electricity was supplied by most Local Authorities, and they had the power to turn these on for the use of all. Therefore, would it not be possible for all heating to be supplied by Local Authorities, so that the whole would be under proper control? Could Dr. Lessing say anything about this, and did he agree?

Mr. T. E. Birtwisle (Sanitary Inspectors' Association), congratulated Dr. Lessing on his excellent paper. Of all the papers he had heard at various conferences, none, he thought, had contained so much information in so small a compass. He would like to ask to what extent could sulphur be removed from coal during carbonization? He had been informed that it was not possible to reduce it by more than 1%.

Mr. R. H. Clayton, referring to Table 1, suggested that the analysis giving 3% of sulphur was a theoretical one in that the high percentage of ash and resulting low calorific figure given would render the material unsaleable.

He agreed that further work on the domestic grate burning raw coal was desirable. Domestic smoke from raw coal was more injurious than factory smoke in that it contained a very large percentage of tar, which is practically absent in factory smoke.

He said there was little hope of the present generation taking much interest in smoke abatement. He therefore suggested the girls of the future generation should be taught in the schools about the injurious influence of domestic smoke in home life, and by so doing get the co-operation necessary for rapid progress.

Dr. H. Osborne (Salford), said that Dr. Lessing had suggested they should use all available methods for smoke abatement. Following up a suggestion of Professor Boys regarding the suitability of a firebrick hearth for burning coke, the Salford Corporation Health Department had, 10 years ago, adopted a new firegrate for the use of high temperature coke, and had converted altogether 60 firegrates. In addition to having no smoke emitted from the chimneys, there had been a saving of 40% in the fuel bill. They had tried all kinds of smokeless fuel, but found the vertical coke to burn most successfully. They had since converted all the firegrates in a local Maternity Hospital to coke-burning grates.

The sulphur emitted from the burning of coke did not go into the room, but was poured into the air. Therefore they must get rid of the sulphur in coke, and further research on this question was essential,

Councillor Alex. Munro (Scottish Branch N.S.A.S.), thanked Dr. Lessing for his paper, and said it was one of the best ever presented at the Conferences. In Glasgow the smokeless fuel prepared by the Corporation (called "Dalcole") was being used in all their hospitals.

The price of coal in Glasgow was being increased, owing to the prosperity of the electrical industry. Councillor Munro said he was in favour of electricity in the home, as in coke there was found to be .8% of sulphur, and electricity was being supplied very cheaply in Glasgow—10 units for 3d. In England coke could be sold cheaper because coal could be procured at a less price. He suggested that the Government should support the coal industry, for what was the use of increasing the efficiency of generation in order to lower the price of electricity, when the price of coal was increasing and cancelling out the saving?

Alderman David Adams (Newcastle-upon-Tyne), congratulated Dr. Lessing on his most valuable paper, which he thought should be combined with the Manchester resolution adopted at the Annual General Meeting.

As a result of the Conference a great amount of practical work should be done by local authorities, particularly re new Housing schemes. He quoted the case of Newcastle, where coal could be obtained 15% cheaper than coke, but a coke fire might save 50% on present coal bills.

Dr. Lessing, in reply to the discussion, said that the aim of the Society should be to keep a sane and just balance when considering the various possibilities and methods of achieving its object, the avoidance or abatement of the pollution of the atmosphere. The Society should present a united front and rather than indicating preferences for individual smokeless fuels or methods of heating over others, should direct its energies towards that large balance of fuel supply which is used without regard to polluting effects. As an old member, having served on the Council for over 30 years, he would urge that the work should not be carried on in a short-sighted way by discussing petty differences between existing methods which were already contributing towards the solution of the problem, but it should aim at establishing the real facts of atmospheric pollution and assist in getting this work done.

The main object of his paper was to analyse the facts responsible for atmospheric pollution so that their relative importance could be appreciated.

Mr. Clayton, when referring to Table I, had assumed it to be based on theoretical considerations. He (Dr. Lessing) could assure him that the data were obtained in actual practice on a very large scale. Coal was still produced in this country which contained as much as 3% of sulphur, and consumers did not find it easy to secure large supplies of coal of a sulphur content low enough to satisfy their requirements. It was, however, only fair to say that the work

embodied in Table I had been carried out 5 years ago and that a very great deal of progress had been made during this time in the perfection of processes for the cleaning of coal and the cleaning of flue gases.

Whilst by efficient coal cleaning a considerable amount of sulphur-bearing impurities, such as pyrites were removed, the clean coal still contained that sulphur which was in organic combination with the coal substance. Although the sulphur percentage in clean coal might not be very greatly reduced from that in the raw coal, the total tonnage of sulphur burned was, of course, considerably diminished by the elimination of the useless sulphur-bearing impurities.

Somewhat similar considerations apply to the behaviour of sulphur during carbonization. A portion was taken out during that process with the tar, ammonia liquor and gas, but another portion became fixed to the carbon in the coke, with the result that coke, or for that matter, semi-coke still contained sulphur roughly in the same proportion as coal. During the burning of coke the sulphur was converted by combination with oxygen into sulphur dioxide gas which escaped into the atmosphere with the flue gases.

It might be said that every commercial fuel contained sulphur, and a small trace was even retained in coal gas, although gas purification reduced sulphur nowadays below the statutory limits which were formerly imposed on the gas supply of the Metropolis.

Mr. Dibblin had raised the question of cost of coal cleaning. Obviously cost was incurred in respect of the actual cleaning operations and of the loss of tonnage. The savings mentioned in the paper were the net effect of the advantages accruing from the use of clean coal after allowing for these costs. Hitherto only the nut and slack sizes had been submitted to dedusting and cleaning processes, and often the cleaning efficiency was not of a high order. There were, however, instances of lump coal for household purposes being cleaned by the gravity process resulting in a great reduction of the clinker produced from it.

Dr. Lessing expressed appreciation of the useful work done by the Manchester Smokeless Fuels Committee. The expenditure voted by the City Council for this work, to which Mr. Clayton had referred, was, however, totally inadequate for attempting a solution of the whole problem, and was very small when compared with the money spent on research and experimental work in the elaboration of the flue gas cleaning plants as installed at Battersea and Fulham.

He endorsed Alderman Waddington's plea for the supply of heat by public utility undertakings. Much progress had been made abroad in this direction by distribution of steam or hot water over relatively large districts, particularly in America and Switzerland. The centralization of generation would certainly facilitate the application of preventive measures.

The erection of high chimneys at power stations, whilst possibly affording some amelioration in the immediate neighbourhood, could not be regarded as a solution of the problem, as the polluting matter is merely diluted and shifted elsewhere but is not made innocuous.

In conclusion, Dr. Lessing expressed his conviction that progress would not be made by compulsory methods but was only possible as the result of research and the application of its teachings. The enthusiasts for smoke abatement should be certain of their ground when using economic arguments on the direct loss occasioned by the emission of black smoke. Detailed knowledge of the factors contributing to atmospheric pollution was still sorely needed, and in his submission the Society could employ its standing and resources most usefully by urging Government and local authorities to establish the survey of the sources of atmospheric pollution which he had suggested.

C 31

A 23

1935



SMOKE and AVIATION

CONFERENCE

ON

SMOKE and AVIATION

held in the

Caxton Hall, Westminster

on

THURSDAY, MAY 30th, 1935

Chairman: The President, H. A. DES VOEUX, M.D.

C O N T E N T S

Smoke and Visibility, by C. S. Durst, B.A., Assistant Superintendent, Meteorological Office, the Air Ministry	3
The Effects of Smoke upon Flying Conditions, by William Courtenay	19
The Effects of Smoke upon Flying in the North of England, by Alan Goodfellow	25
Visibility and Smoke in Relation to Aerial Photography, by Captain Alfred G. Buckham, F.R.P.S. (with photographic illustrations)	29
Discussion	36

NATIONAL SMOKE ABATEMENT SOCIETY
36 KING STREET MANCHESTER, 2

Price — ONE SHILLING.

The aerial photograph of Edinburgh on the cover of this Report is by Captain Alfred G. Buckham, F.R.P.S. and is one of those exhibited by him during the meeting. We are indebted to Captain Buckham for his kind permission to use the photograph in this way.

SMOKE AND VISIBILITY.

By C. S. DURST, B.A.

Hygroscopic Nuclei.

In any sample of air taken from near the surface of any part of the globe there are always present a number of minute solid particles. These particles are so small, that they have practically no rate of fall, but float in the air and are borne hither and thither as the wind blows. Though so small the particles are of the greatest importance in the science of meteorology on account of what is called their hygroscopic quality. This quality is such that when the invisible water vapour, which is a constituent of the air, reaches a certain degree of saturation it is able to condense on the particles and they become the nuclei of minute drops of water. In some cases the droplets are visible as cloud or fog, in other cases they are so minute that they are almost invisible, in yet other cases they become large enough to fall as drizzle or rain or even as the big drops of a thunder shower.

It has been found that in many cases these nuclei of condensation are particles of salt thrown up from the sea surface, and carried far over the land by the wind. But in addition to the salt hygroscopic nuclei there are others directly due to the processes of combustion including sulphur trioxide. These latter have an important function in the formation of fog over and in the neighbourhood of the land areas of the globe, but it is well perhaps to emphasize that many sorts of dust, such as road dust, do not act as hygroscopic nuclei.

As has been mentioned above the humidity of the atmosphere must exceed a certain value before condensation on the particles can take place. That value will vary according to the nature and size of the nuclei. The relative humidity being dependent on the temperature it is natural that the limiting of visibility owing to the condensation of droplets occurs often from the cooling of air by contact with a cold ground surface.

The picture of the atmosphere that I would draw then is one in which there are a great number of these minute particles floating freely in the air, some of which obscure the atmosphere only by their presence, while others may obscure it not only by their intrinsic size but also by the size of their surrounding water drops.

The Measurement of Visibility.

The amount of the obscuration is measured usually in terms of the visibility of distant objects. A scale has been drawn up for international use in which the distances of the

objects are laid down, the sizes of objects selected being such that in clear weather they are easily seen. How easily any object is seen depends considerably on the contrast between it and its background and this factor enters into the visibility as measured. To realize exactly what these measurements mean let us consider how the presence of nuclei will affect the visibility. The light from both the object viewed and from its background will be dimmed by the obstruction of the particles, the definition of its outline will too become blurred and on this account the object will be less easily recognized. In addition to obscuration on this account there is the effect of glare; light from the sun and sky falling on the droplets or particles will be reflected into the eyes of the observer and the contrast between the object and background will be lessened because the medium through which it is seen is bright. An example of this is the case of the motorist who saw a signpost on a foggy night, but could not read the names on it. He turned his headlight on and the signpost disappeared from view, on account of the glare from the intervening drops.

From what has been said above it is seen that the problem of visibility is complicated not only by the size and composition of the nuclei and the humidity of the atmosphere but by physico-psychological factors. It will also be realized that the comparison of visibility by day and by night presents the greatest difficulty and indeed at the present stage of our knowledge cannot be attempted on any rigorous basis.

The Normal Frequency of Visibility.

To turn now to the more practical side of the question, let us consider how far smoke from towns is likely to reduce the visibility and under what conditions this reduction is likely to be most marked.

In Fig. 1 is shown a series of graphs which indicate the normal frequency that objects beyond certain distances were invisible at certain places in summer and winter. The horizontal scale represents the distance beyond which the object was invisible and is a logarithmic scale for the sake of convenience in representation. The vertical scale gives the percentage frequency. Curves for summer and winter are given for each place. The places used in this diagram are Scilly which represents a sea exposure, Birr Castle in Ireland, a rural exposure uncontaminated by smoke. Croydon and Kew, urban exposures and Cranwell, a rural exposure which is however contaminated by the smoke pollution of the Midlands. As would be expected the curves for Scilly and Birr Castle show that visibility at those places is much more

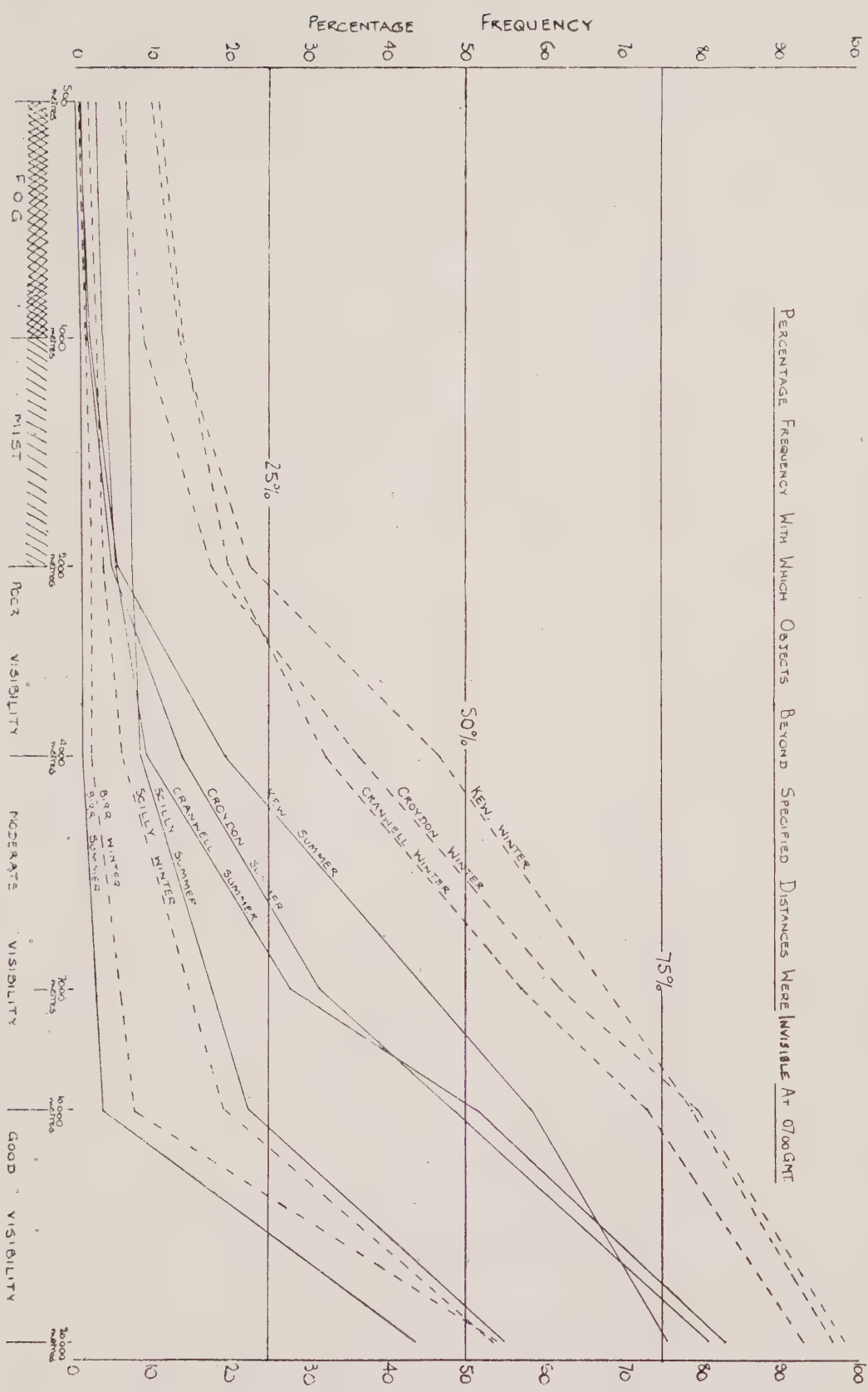


FIG. 1.

often moderate or good than at any of the others, both in winter and in summer. Croydon and Cranwell each have nearly the same frequency of moderate and good visibility while Kew is definitely worse. A result that also is to be expected is that the summer visibilities are better than those in winter at each of the land stations. At Scilly, however, the visibility is better in winter than in summer, a characteristic which is a feature of sea exposures.

In reviewing these curves it must not be forgotten that even in an unpolluted atmosphere the frequency curves of visibility will be affected by the prevalence of certain purely meteorological conditions, so that we cannot put down to pollution the whole of the contrast between the curves of say Birr Castle and Kew. It is, however, impossible to avoid the conclusion that a very large proportion of the contrast in the frequency of moderate visibility is directly due to the greater pollution over England. If then this is conceded it drives home all the more emphatically that the rural air, as shown by the Cranwell observations, is as vitiated as that of Croydon.

The Reduction of Visibility over the British Isles from Smoke.

That this is so may be shown from another angle. If we assume that droplets do not occur on more than 25 per cent of mornings, and if we then take the average visibility observations of a period of years and find for each place what distance is visible on, say, three-quarters of the mornings, we can get a criterion of the extent to which smoke limits the visibility that is comparable for the different places. This has been done for a large number of stations over the British Isles and the result is shown in Fig. 2. In that diagram the figures give, in kilometres, the distance beyond which one can see on three-quarters of the mornings. Lines have been drawn through points where that distance is 15, 10, 5 and $2\frac{1}{2}$ kilometres. It will be seen that the west coast of Ireland and Northern Scotland experience the best visibility; there is a general deterioration to south-east, the worst place being London. Glasgow and Dublin have little patches of bad visibility of their own and the smoke of South Wales can be seen to affect Bath and Cheltenham. Such a chart as this emphasizes how much the visibility over a closely populated country is limited by smoke.

The Frequency of Fog at Various Stations.

The effect of smoke on moderate visibility has been dealt with first because that problem is comparatively simple. Its effect on the formation of fog is very much more complicated

DISTANCE IN KILOMETRES WHICH IS VISIBLE
ON 75% OF OCCASIONS

15Kms.

10Kms

15Kms

5Kms.

5Kms.

5Kms.

5Kms.

The frequency of fog at certain stations at 0700 G.M.T. and 1300 G.M.T. is given in the table below:—

TABLE I. Percentage frequency of days of visibility below 1000 m.

	0700 G.M.T.				1300 G.M.T.			
	Summer		Winter		Summer		Winter	
Birr Castle	0.9	...	1.6	.....	0.0	...	1.1	
Scilly	7.1	...	3.0	.....	4.7	...	2.5	
Aberdeen	3.4	...	0.8	.....	0.2	...	1.9	
Aldergrove	1.4	...	4.9	.....	0.0	...	3.1	
Sealand	1.6	...	11.5	.....	0.1	...	4.6	
Cranwell	3.7	...	14.6	.....	0.1	...	6.0	
Worthy Down...	3.0	...	11.5	.....	0.0	...	2.8	
Ross-on-Wye ...	3.6	...	8.0	.....	0.1	...	4.9	
S. Farnborough...	2.0	...	11.9	.....	0.0	...	6.2	
Renfrew	2.6	...	9.2	.....	0.0	...	10.9	
Birmingham ...	3.9	...	14.0	.....	0.3	...	14.9	
Croydon	1.6	...	9.0	.....	0.0	...	8.9	
Kew	2.0	...	13.7	.....	0.0	...	12.1	

The outstanding features of this table are the high frequency of summer fog at Scilly which is characteristic of a sea exposure and the comparatively large incidence of winter fog in the morning at Cranwell, South Farnborough, Worthy Down and Sealand, which are none of them liable to excessive atmospheric pollution. These fogs are primarily due to the cooling of the lower layer of the atmosphere at night. When the sun rises in the morning its heat tends to dissipate the fog in country districts such as those. In suburban districts as represented by Birmingham, Croydon, Kew and Renfrew the dissipation of winter fog does not occur because of the smoke admixture and indeed the fog is actually more common at Birmingham and Renfrew at midday than in the morning. So we learn that though country fogs owing to topographical conditions may be as frequent as suburban fogs they are not so persistent.

The Conditions for Fog Formation.

Let us now consider briefly how the conditions for fog arise. Heat is leaving the earth's surface at all times by radiation, but during day time, even when the sky is cloud covered, the surface is also receiving heat by radiation from the sun so that on balance the ground is gaining rather than losing heat.

At night the total amount of heat lost by the earth's surface by this process of radiation is dependent on whether

clouds are present or not. If clouds are present, they too act as radiators and some heat is received by the earth from them. (It is for this reason that clear skies are favourable to frosts).

Thus on clear calm nights a layer of cooled air will form over the surface of the ground, and since cold air is heavier than warm, it will trickle, like water, down the slopes of hills and collect in the valleys. If that air contains enough water vapour it may be cooled below its dew point and fog will form over the lower lying ground. Such a formation is beautifully illustrated by a photograph made by Mr. C. J. P.



FIG. 3

Cave of fog near Petersfield a reproduction of which is given as Fig. 3.

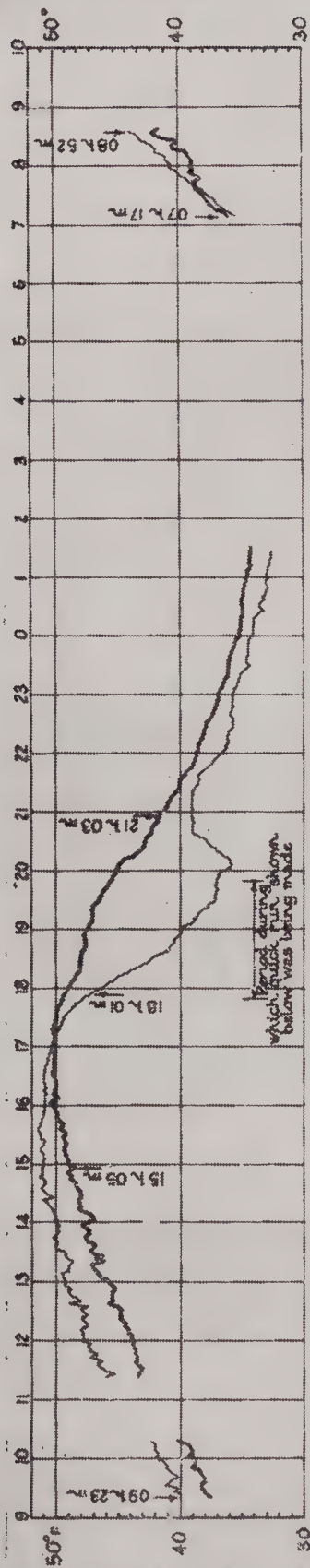
Here it is necessary to make a short digression and to explain briefly something of the thermal structure of the atmosphere and its effect on mixing of air masses.

Normally the temperature of the air decreases as height increases and when the decrease is as great as $5\frac{1}{2}^{\circ}\text{F.}$ in 1,000 feet the rising and falling of small air masses becomes easy, the aviator experiences bumpy conditions and gustiness increases. On the other hand if the temperature increases with height, the rising and falling of small air masses becomes exceedingly difficult and gustiness is damped down. These

CARDINGTON AUTOGRAPHIC RECORDS APRIL 6-7 1929

Form 463:

97



Electrical Temperature Record.

The thick line indicates temperature at 143 feet above ground level at station F, the thin line indicates that at 840 feet above ground level at station G. Station G is 28 feet below ground level at station F and 840 feet horizontally from it.

Normal Anemogram for period April 6 08h.37m.20s. to April 7 09h.18m.10s. at height of 50 feet above ground (Station H).

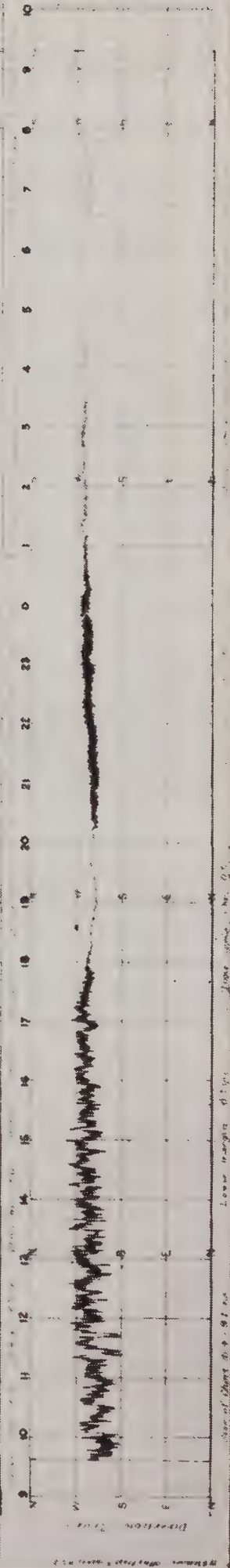
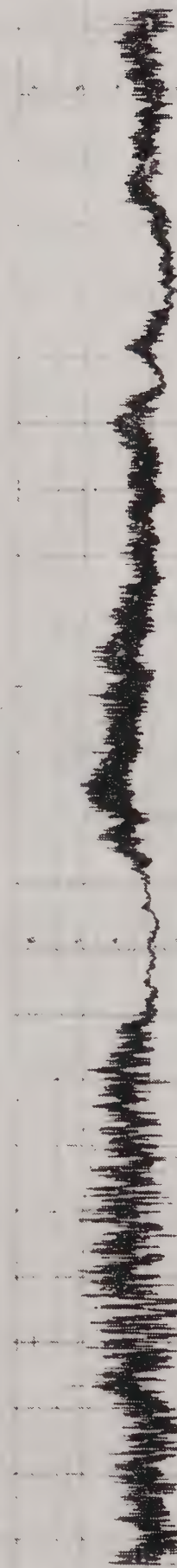


FIG. 4

features are well illustrated by the wind records made at Cardington and illustrated in Fig. 4. On this figure are given the Dines pressure Tube Anemogram for April 6-7, 1929, at 50 feet above ground level and the recorded temperatures at 4 feet and 143 feet above ground. The Dines Anemogram shows both the speed and direction of the wind; the temperature records, which are given in the upper part of the figures, show the temperature at 143 feet by a thick line, that at 4 feet by a thin line; in each case the record is for a full 24 hours, though unfortunately there are some breaks on the temperature traces. It will be seen that soon after 17 hours (5 p.m.) the temperature at the higher level fell below that at the lower level and what is termed an inversion formed; at nearly the same time the anemogram which before then had shown many rapid oscillations (gusts), became almost a straight line indicating that the air was flowing smoothly past the anemometer. This is a very characteristic effect of an inversion and when it is occurring the fog or smoke below the top of the inversion is not churned up and dissipated into the upper air. The formation of inversions near the surface only occurs with light winds and hence fogs are mainly confined to such occasions as those when anticyclones are lying over the country under which conditions clear night skies and light winds are apt to occur simultaneously.

Some Examples of Fog Formation.

It is not proposed to go here into the details of all the types of meteorological situation in which fog can arise: that has been done by Entwistle¹, it will be well, however, to reproduce one or two examples from that paper. In Fig. 5 is shown the pressure distribution on February 12, 1927, when radiation fog (indicated by the stippling) was prevalent over England, France and Germany. Attention should especially be paid to the diagram on the right which shows the upper air temperatures observed at Duxford on that day and brings out strikingly the inversion between 2,000 and 3,000 feet which prevented the fog and smoke from being dissipated upwards. From the wind directions it is seen that we were then receiving pollution from Germany and Belgium in addition to our own smoke.

Another example in which the inversion of temperature was due to a warmer current of air flowing over cooled land is shown in Fig. 6 and in this case the smoke from England was a contributory cause to the fog over Belgium and Germany.

¹ Entwistle F. Fog Journal of the Royal Aero Soc. 1928.

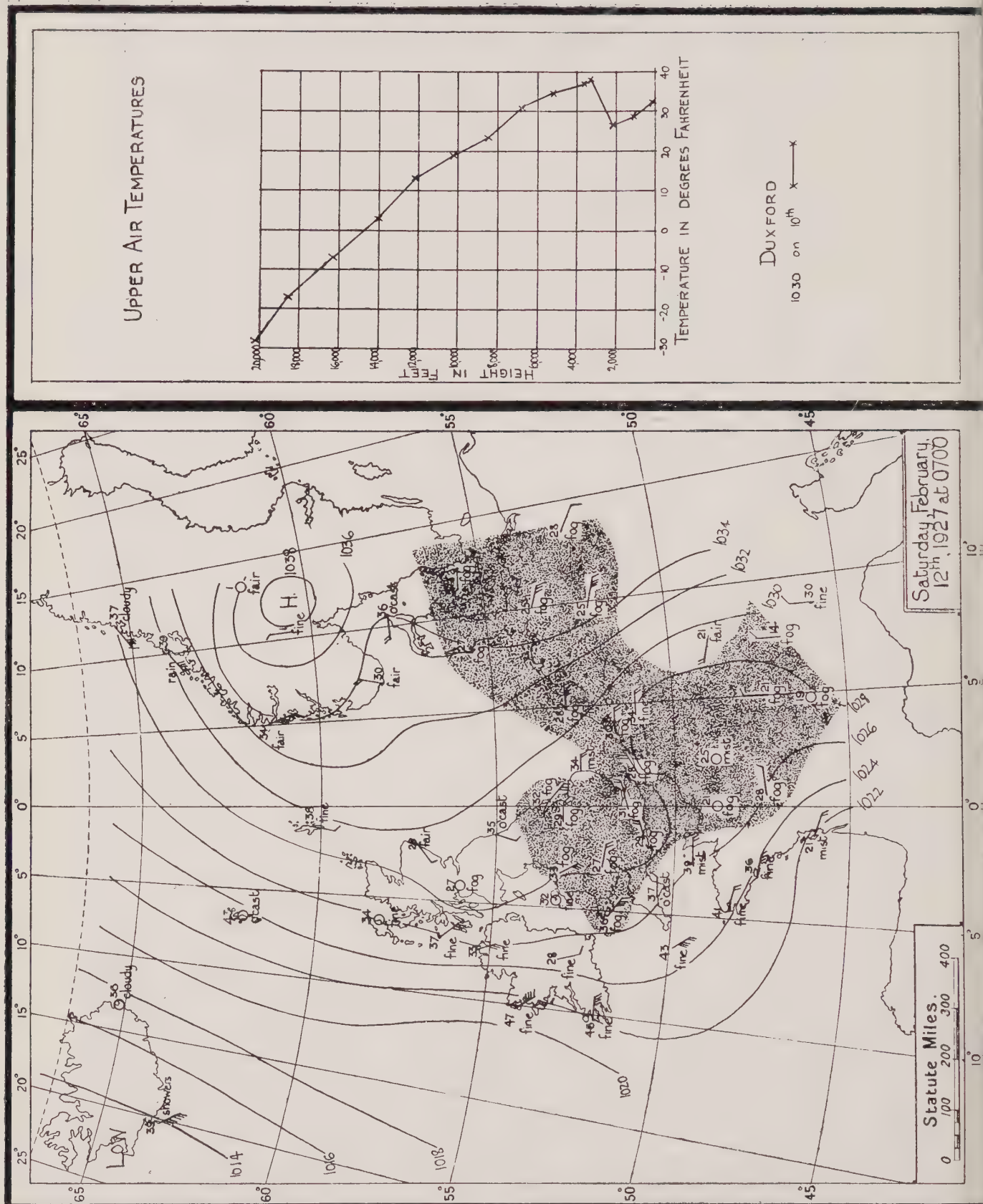


FIG. 5

In these two cases fog occurred at the surface, but given a suitable distribution of temperature with height, fog may occur at some height above the surface though horizontal visibility on the ground is not seriously affected. Such a case was that of November 25th, 1927, shown in Fig. 7. In that case the smoke of London was trapped at a height of 3,000 feet giving a black pall through which the sunlight could not penetrate. The result is well shown by the photograph in Fig. 8 which was taken at midday and shows vividly how London had all its lights lit.

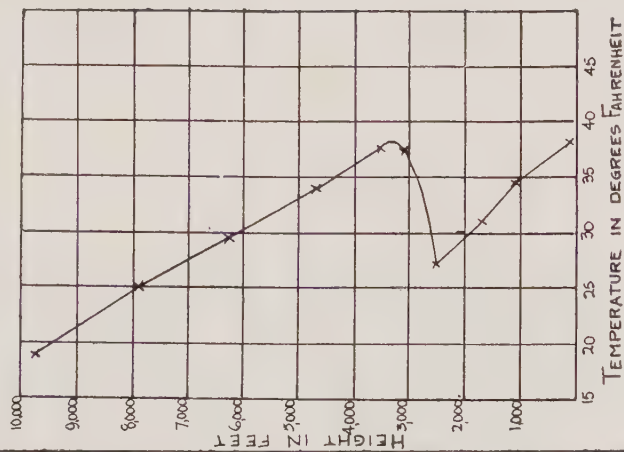
The Diurnal Variation of Visibility.

This review would not be complete without a brief reference to the diurnal variation of visibility. In Fig. 9 are shown the frequencies of visibility below 1,000 metres (fog) and below 4,000 metres at Croydon for each season. It will be seen in each case there is a decided increase in frequency of poor visibility about an hour or so after sunrise and again towards sunset. There are also added for comparison the diurnal variation in the amount of pollution present at South Kensington in summer and winter. To some extent the curves of pollution and visibility march together, but it is to be noticed that the morning increase of pollution at any rate in summer occurs later than the increase of poor visibility. Hence smoke cannot be held to be responsible entirely for the worse visibility after sunrise.

The Effect of Fog on the Selection of Aerodrome Sites.

At the present time when aerodromes are being laid out in the neighbourhood of the majority of our larger towns, the importance of a clean atmosphere is being thrust more and more on the municipal bodies. For fog and poor visibility is one of the worst enemies of the regular operation of aircraft. From what has been said above it will be realized that the pollution of an industrial area is so widespread that an aerodrome may be subjected to the smoke nuisance of a town far away or even that from a foreign country. Yet in the selection of an aerodrome site it is essential to take into account sources of pollution in its immediate neighbourhood and to choose the windward rather than the leeward side. In this country where winds are most commonly from the west or south-west, the north-east side of a town has usually the worst visibility, the south-west the best. On the other hand this is not an unfailing rule for allowance must be made for the nature of the soil and the lie of the land; a site for instance near a river and especially near one that flows through water meadows is likely to be more prone to fog than a site higher up

UPPER AIR TEMPERATURES



DUXFORD
10.15 on 23rd x—x

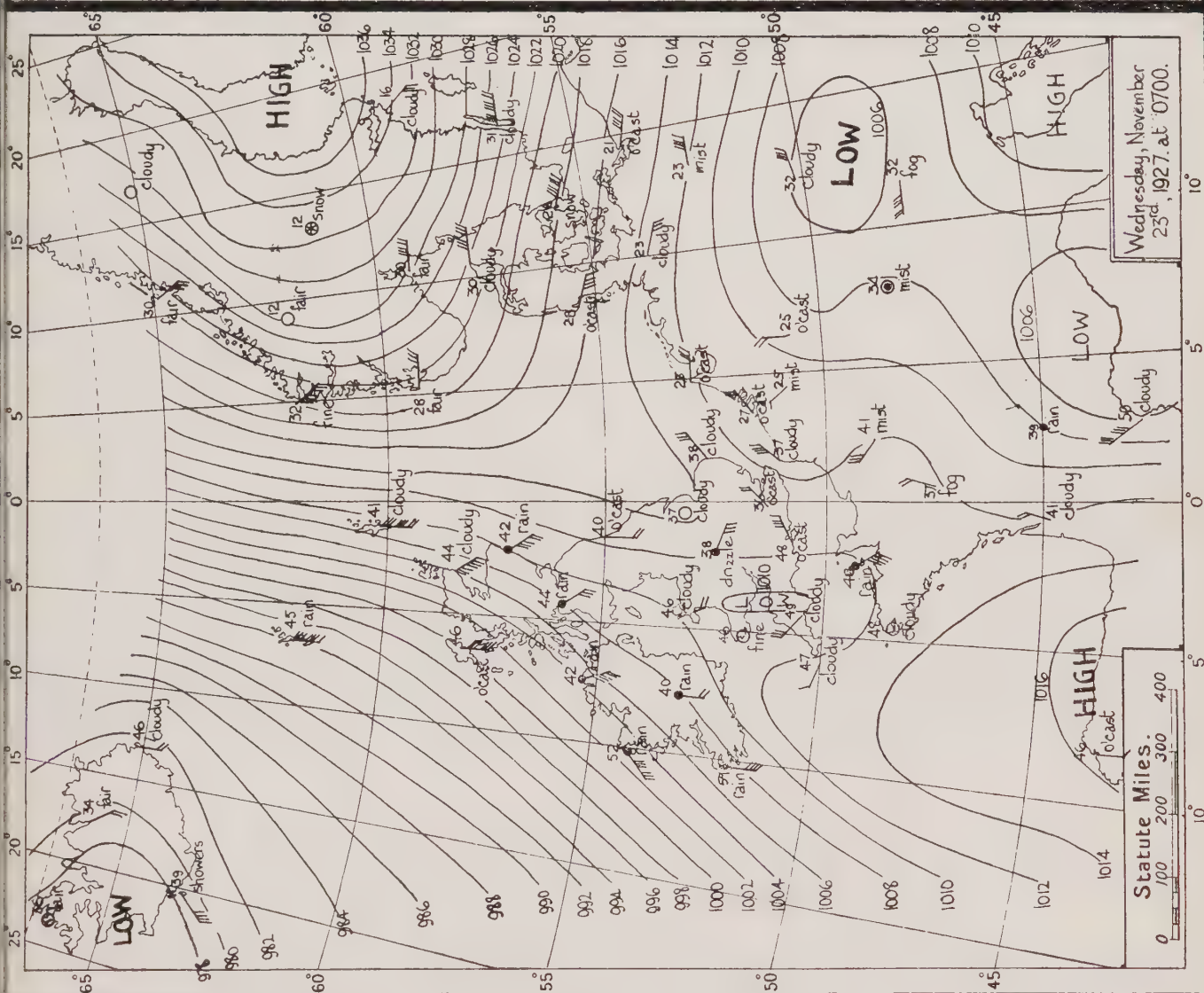


FIG. 7

and away from water surfaces, even though the former may be to the south-west and the latter to the north-east of an industrial area. The comparison of visibilities at two such places would probably show a higher frequency of foggy days at the south-western site but a higher frequency of days with poor visibility at the north-eastern.

The Vertical Variation of Visibility.

It has been pointed out earlier that the pollution from



FIG. 8

industrial areas extends for great distances to leewards. As a general rule it may be stated that as the pollution is carried further and further from its source it will be also disseminated to a greater and greater height unless there is an inversion present at some level. The presence of such an inversion in the upper air is by no means uncommon and it is often the case that above such an inversion the horizontal visibility is

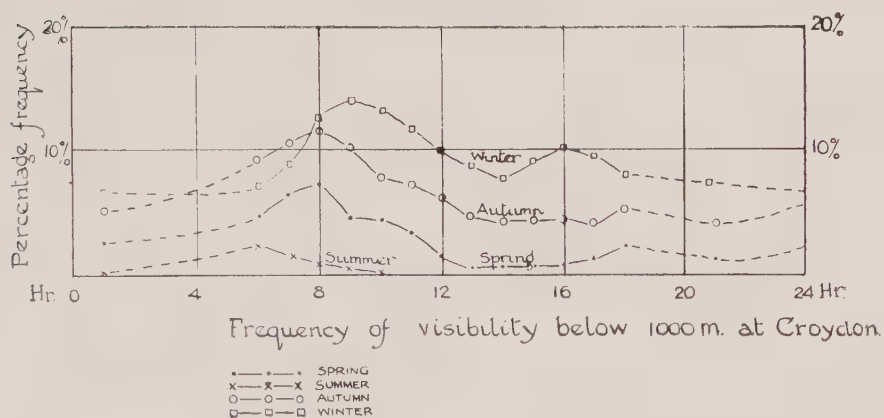
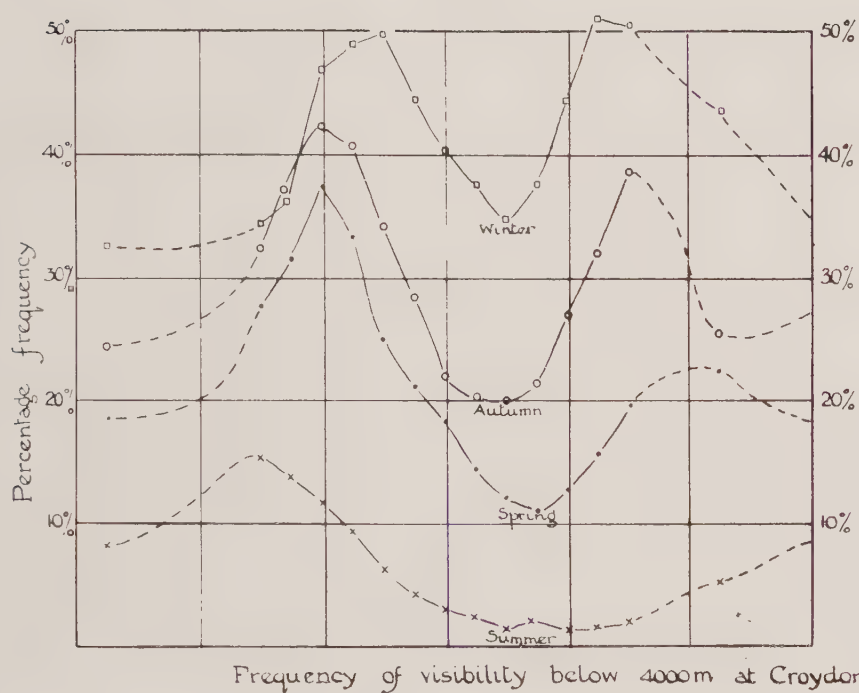
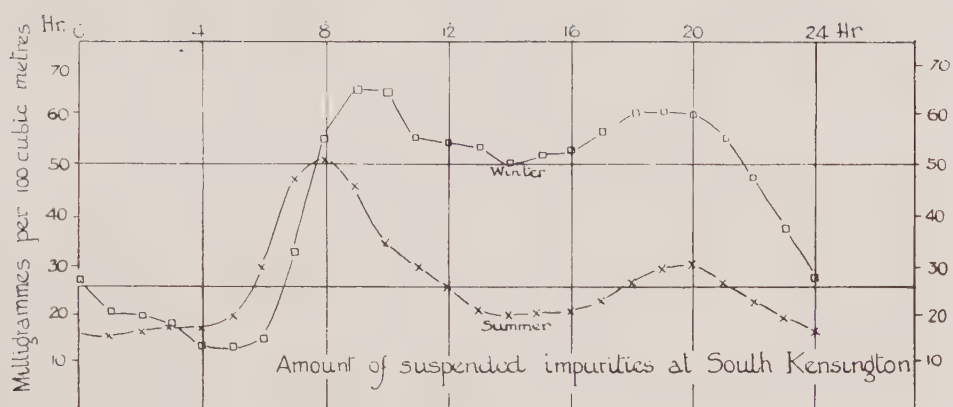


FIG. 9

exceedingly good, though the downward visibility is very poor as the line of vision in the downward direction passes through the smoky atmosphere beneath the inversion. As an example may be quoted some visibility observations made from an aeroplane which left Croydon on the morning of March 12th, 1935. The surface visibility was 4,000 metres, at 500 feet the visibility had dropped to 2,000 metres only, at 1,000 feet it was again 4,000 metres, while at 1,500 feet it was as much as 8,000 to 10,000 metres. Thus visibility may differ very greatly at different heights, indeed the upper surface of a fog is often quite abrupt.

Conclusion.

To sum up what has been concluded from this paper. Fog will occur whether there is atmospheric pollution or not. To some extent the frequency of fog is dependent on the amount of pollution but to a greater extent the persistence of fog is due to the presence of smoke. Smoke tends to cut down the range of vision when no actual fog is formed and over the British Isles there is a general deterioration of visibility on that account from west to east.

Acknowledgment.

I am indebted to the Controller of H.M. Stationery Office for permission to reproduce Fig. 4; to the Council of the Royal Aeronautic Society for allowing me to use the illustration shown as figures 3, 5, 6, 7 and 8; and to the Director of the Meteorological Office for his consent to make use of the data in the records of that office.

SMOKE ABATEMENT AS IT AFFECTS LONDON.

By WILLIAM COURTENAY,

Air Correspondent, London "Evening Standard."

The effect of smoke on flying in the South of England is to a large extent bound up with the question of poor visibility arising through fog, low cloud or other conditions of a like nature.

All those of us who have owned our own aeroplanes and who fly a great deal about this country know that a smoke pall hanging over a big city such as Birmingham, generally both betrays the presence of a city and acts as a navigation guide.

It is particularly strange I always think to see this black pall hanging lazily over a city on a warm summer day when there is a cloudless sky and an absence of wind. Not until one sees this obnoxious mantle does one realize that down below are millions of people living in blissful ignorance, or I should say dangerous ignorance, of the fact that their blue canopy above is polluted every minute they are breathing. I think if more of them saw it in such conditions there would be an outcry to control smoke or abate its nuisance.

Then again over London particularly on days of continuously good weather one finds a haze hanging about due largely to smoke which has not drifted away, while beyond is perfect visibility of perhaps several miles.

This haze can sometimes be almost impenetrable to the eye, a positive danger to navigation in crowded areas of the sky, and the beginner at any rate can quite easily get lost because of it or even come to grief. Steering a course through it to get on to one's track from perhaps Croydon in the South to Hendon and Hatfield in the North can have its minor terrors for the inexperienced. It hangs around for days. Smoke is the agent responsible for this evil. One generally flies to windward of a smoke pall over a city so that any wind there may be will drift it away from one's path of flight. It often entails quite a detour to get back to one's track. It can be particularly dangerous when many air liners are arriving at or departing from a city aerodrome and when the pilots of incoming and outgoing machines cannot see either very far ahead or any other machines in the vicinity. It is going to present municipalities with a problem of traffic control in the air over their cities once the air lines develop sufficiently to require it.

Air Traffic Control in London.

This brings me to my main theme which is the system of traffic control in use round London's aerodromes and which conditions of the smoke pall no less than fog and low cloud have necessitated.

There are now something like 40 arrivals and departures daily from London's Airport at Croydon alone while Heston on the west side of the Metropolis is just as busy. This takes no account of the large number of desultory journeys made by the air taxi firms; the joyriding concerns; and the private owners.

In fact so serious has the problem become at Croydon that the latter are not really wanted there. You cannot forbid me from landing at a civil airport if I own a second hand Moth. But I am a nuisance at a busy commercial centre like Croydon. To scare me off I am charged 3/6 every time I land while should I leave my machine out and should it be put in a hanger for the night by the aerodrome staff there is a bill for about 12/- next day for its bed and breakfast. I could almost put it up at the Ritz for that. It is quite natural that the Traffic Control Officers should regard the private flier who generally has no wireless as a nuisance.

The whole secret of proper air traffic control over a big city when cloud and smoke have joined hands to reduce visibility to almost nil, is to be able to plot the course of every aircraft in the vicinity. Recent regulations have been codified to make this control very complete as from May 15th so that it is very appropriate you should be considering the question to-day.

At Croydon we have the most perfect system of air traffic control yet devised in this country or perhaps anywhere else. All we lack so far is a system for blind landings, but this will follow this year.

As most of you probably know if you travel by Imperial Airways to Paris, the pilot of your air liner is in constant communication by wireless with the officers in the Croydon Control Tower all the while your flight is in progress.

As soon as the air liner ascends at Croydon the first officer who acts as wireless operator unwinds his trailing aerial and calls up the Control Tower to test it. He reports the aircraft's registration letters and other particulars of identity and his destination. He then gets on his course. This is done by the way, with wireless telephony and if you were to stand in the Control Tower on a busy day or any day you would hear these reports coming through a wireless set. Indeed you can pick them up at home as many listeners do.

Imagine then conditions of fog where smoke combines to reduce visibility to nil. The air liner is lost to view in the white mist before it has travelled 100 yards across the aerodrome. The pilot is following a white line on the ground to keep the machine on its track for the take-off.

With the aid of his "blind flying" instruments he can keep the machine on an even keel, turn her on to the course for the continental destination, and trim her straight once more. He cannot see the ground at all. He has lost his eyes. But wireless becomes his second sight. All the way down to the coast he can telephone Croydon to ask for bearings. As he leaves the coast Croydon will tell him exactly where he is. Once over the Channel it is customary to change over to wireless telegraphy and work in morse to the foreign stations in Europe where language difficulties might otherwise prove a barrier. And so to Le Bourget aerodrome at Paris. He can be guided right to the aerodrome boundary by flying on his compass course and by relying for drift corrections on the bearings he is given from the aerodromes. They tell him exactly where he is within 75 seconds of his wireless enquiry. He can then check his position by reference to his maps and decide whether a beam wind is drifting him off the track he should follow or not. He can make a compass correction accordingly for while he will have known the wind strength and direction at the take-off and will have a forecast for the route, changes may arise according to his altitude which may cause drift. He can only allow for this when he can see the ground and check it the moment he deviates from the line on his map. But he cannot see the ground in the conditions we are describing.

This is all very simple so far. The difficulty begins when many machines are calling for bearings at once. Then the lines become busy and the Control Tower officials are likely to become very harassed though if you saw them at their work plotting the positions and courses of air liners they cannot see, you would be filled with admiration for their skill.

"Q.B.I."

In conditions of poor visibility when you cannot see 1,000 yards ahead of 1,000 feet up, a mysterious signal hangs out at Croydon. You will notice it sometimes when you fly there. It is a yellow board diamond shaped and not more than about 12 inches in length or width. On it are the cryptic letters in black "Q.B.I." This informs all and sundry that bad weather conditions are about and the Controlled Zone is in operation. Heston and Hillmans Aerodrome at Stapleford Abbots, Essex, Lympne

on the coast, Gravesend in the track of the continental traffic and other airports all hang out this warning to pilots.

Now for a radius of 15 to 30 miles from Croydon all air liner movements inward or outward are controlled by the brain on duty in the Control Tower. It may be fog or low cloud or generally a combination of one with a smoke pall which has produced the bad conditions.

No liner may now leave Croydon or Heston or Essex Airport without permission from Croydon. The Control Tower officer gives the pilot his turn for taking off, knows his destination and the compass course he is to follow. His altitude is even determined for him and with this knowledge provided the pilot obeys implicitly these instructions, no collisions should arise in smoke or cloud.

Then the inward liners are crowding fast towards Croydon to keep to their advertised time-tables. From Berlin, from Brussels, from Amsterdam, Paris, and other places farther afield they bear down on the bottle neck which leads from the coast to London's airport.

The Control Tower is in touch with them all by wireless. As each approaches the airport he is asking for his bearings. He is given them and is told at what height to fly and where to wait until he is given his turn for landing. In this way all can be brought safely home to their haven, which until they reach the aerodrome boundary they probably cannot see.

Even the air maps have to be marked by well defined paths which the air liners must take on their way to and from the coast and London. Private flyers and air taxis and others must give these lanes a wide berth.

The real danger arises from the machine not equipped with wireless. All air liners are so equipped of course and I think all air taxis should be compelled to use it as they often have to go on urgent duties whatever the weather. But the private flier not only does not possess it but is not encouraged to do so.

This is because only a limited number of wave lengths have been allotted on the band for aviation. So many have been given up by the International Radio Conference to amusement and entertainment. We cannot afford to let the private flier on the air as yet as he causes congestion to the air liner. Not until 1937 when the next Conference meets in Cairo can this state of affairs be remedied and only then if there is a concerted demand for more elbow room on the air for the aeroplane.

The Private Flyer.

The private flyer might take off from any commercial or private aerodrome which is not an airport with a traffic

control officer. He may get a weather report as he ought if he is wise before starting a journey. He may not bother if he feels very self-confident.

He might barge into the airway of the controlled zone and finding himself in thick weather, perhaps without blind flying instruments may get hopelessly lost. He can then become a danger to aerial navigation as the Control Tower may not know of his presence and the officers are plotting the courses of air liners ignorant of the fact that he is in the way. Disaster might follow.

Actually provision is made for this and the private owner without wireless must not enter the Zone if it has come under control when he takes off from his home station. He knows then that if he is near it on his flight he must land outside it; phone Croydon from the ground for permission to proceed; and act on instructions. As long as he does this no damage can be done.

But there is a lot to be said for the private owner and our numbers are very few, only about 500 and not a growing number really, because restrictions may gradually force us out of the air, though I do not think it will come to this. The small two seater cannot find space for a wireless set for one thing. Secondly the private owner does not as a rule want to learn wireless and take the necessary licence to operate the set.

It may interest you to know how Croydon can tell the pilot of an aeroplane perhaps 100 miles away and which he cannot see, exactly where he is. It is done in this way. By an instrument at Croydon and another at Lympne and a third at the old airship station at Pulham, Norfolk, operators listen in all the time. Calls from aircraft are located and by turning a device the strength and weakness of the call is registered. When it is at its strongest then the instrument is directed at the air liner. A graduated scale underneath shows the compass course from the instrument which the air liner is taking. Lympne and Pulham communicate the bearings they have taken to Croydon, where with the one received at the Control Tower the three are plotted on a map of the area. By joining three straight lines the point at which they intersect is the place where the machine was in the air at the moment the call was made. Within 75 seconds this place is communicated back to the pilot.

To-day the country is carved into three areas to relieve congestion, Croydon deals with continental traffic. Heston will deal with the great inland air routes which are gradually

But at all times of the year and not only in winter, the smoke pall over the city can be a menace even when fog and

cloud may be absent. It can cause an elaborate system such as this I have tried to describe, to be brought into operation with always risks of collision, however small, and with risks of dislocation of air traffic and failure to keep schedules. Air traffic in this country will grow as public confidence in it is built. This confidence will gradually arise as the air line operator proves the safety and reliability of his machines. It will be essential both to keep to time-table and to give 100 per cent reliability and efficiency of service. The public accepts no excuses if it has turned up to catch an air liner by an advertised time-table and if the machine is not there. Neither does it show any special praise if the machine is on time. Its approval or censure is shewn in the rise or fall of traffic figures and of profits.

As we shall always have weather difficulties to deal with it behoves us to eliminate those causes of delay or procrastination which can be controlled. And one of them is the smoke nuisance. If we can through the agency of your Society minimize the evils of smoke over our cities, apart altogether from the good you will do by taking this muck out of people's lungs, you will be rendering a service to aviation by one more victory on the road to 100 per cent air services throughout the country.

THE EFFECT OF THE SMOKE PROBLEM ON FLYING IN THE NORTH.

By ALAN GOODFELLOW.

I have been asked to contribute some notes on this problem, based on local experience. I must make it clear at the outset that such experience is very local and I have therefore treated "the North" as applying to that portion of England lying between Birmingham and the Border of which I have personal knowledge. This does not suggest that the problem does not exist north of the Border but my personal experience does not warrant me writing of it since I have only once flown that far. Curiously enough that solitary occasion was largely due to smoke nuisance and may itself serve as an illustration of the problem. I was on a compass course flight to Newcastle and, allowing insufficiently for drift, I struck the Tyne some miles inland from that city. A combination of low cloud and the inland smoke drift from Newcastle created a patch of very bad visibility through which I flew without ever seeing the river and continued gaily on my course until I ultimately landed somewhere in Scotland to ask the way. Had I been carrying a watch (as every cross-country pilot should do) I should have known that the bad visibility at that point could only have been caused by the Newcastle industrial district and that I was therefore passing my destination to leeward, but the illustration may serve as an example of the dangers of smoke pollution to a pilot who has not taken all the necessary precautions.

The difficulties caused by smoke in the North do not I think vary from those of any other part of the country although they are perhaps more acute than in most parts of England. This view is confirmed by Mr. G. F. Yuill, the chief instructor of the Lancashire Aero Club, who is a "blind flying" expert, and to whose assistance I owe much in the compilation of these notes.

Three distinct sets of conditions exist in which the difficulty may be really serious to the pilot of an aircraft.

- (a) In calm and normally clear weather sheets of smoke may be seen lying smoothly across the districts which produce them. The depth averages about 400 feet but varies according to temperature. Generally speaking during the day time with warm temperature the depth is greater and the intensity less. Conversely at night time or with a low temperature the depth is less but the intensity is greater. If the comparatively calm weather continues for a considerable period the banks gradually extend and join up with

other banks until finally there is a wide spread area of bad visibility extending up to 1,000 to 1,500 feet, above which flying is easy provided that the necessary means of navigation are at the pilot's disposal.

- (b) In periods of normally poor visibility, that is to say low cloud and drizzle with little rain, the problem becomes much more serious. The smoke particles mixing with the existing atmosphere produce a mass of obscurity which frequently rises as high as 5,000 feet and covers hundreds of square miles of territory. In such conditions flying may be very dangerous.
- (c) Sea fogs sometimes drift inland far enough to reach a smoke belt. The combined effect is to produce a fog of great intensity in which flying is practically impossible. Usually, however, the boundaries of such areas are sharply defined and the depth of the fog belt is not very great.

Under conditions (a) or (b) bad visibility will invariably be found over the midland industrial areas of Birmingham, Wolverhampton and Stafford, the eastward skirt of the Pennine Range in Yorkshire (against which the smoke layer of the Yorkshire industrial districts seems to pile itself), a well defined area in the North-West of Lancashire lying between the Mersey and the Ribble and finally along the coast of England at the estuaries of the Mersey, Tyne and Humber.

Under condition (a) a skilful pilot will usually reach his destination safely without directional wireless if the aerodrome for which he is heading is well clear of the city (*e.g.* Woodford for Manchester or Cramlington for Newcastle). If, however, the aerodrome is too close to the city or lies in a smoke belt area (as in the case of Barton for Manchester, Hedon for Hull or Speke for Liverpool) he will find difficulty in doing so. It must be borne in mind that in the conditions described only very low flying will enable the pilot to pick up land marks on the ground. This is not only a dangerous practice to have to adopt over a populated area but is rendered doubly dangerous by the obstacles in the near vicinity of many aerodromes such as wireless masts and high tension cables which are exceedingly difficult to distinguish against the murky background.

Condition (b) is much more serious for the private owner or Club pilot than for the Air Line pilot. The former generally depends upon compass navigation together with the picking up of land marks in order to check his wind drift. In the conditions mentioned he is therefore often debarred entirely from cross-country flying. The Air Line pilot on the other hand depends mainly on directional wireless for his

navigation and can afford to ignore land marks, knowing that the wireless will bring him safely over his aerodrome of destination and that provided he has visibility of 400 to 800 yards at that point he can land in safety. His chief danger is the possibility of meteorological conditions causing that curious phenomena known as ice formation. If these conditions arise he may be compelled to fly low in order to avoid the formation of ice on the wings, but otherwise he will normally fly at such a height as to be clear of the smoke bank.

Condition (c) is liable to worry Air Line pilots more than private fliers. The combination of a sea mist and a smoke bank produces visibility which may be as little as 100 yards or less and if such a bank is lying over his terminal aerodrome the Air Line pilot may have to turn back. As mentioned, however, the limits of these belts are very clearly defined and do not usually extend very far inland so that the private owner usually lands in a field on the edge of the bank, makes friends with the farmer, and goes on to his destination by road.

Those who wish to make a study of the effects of smoke on air navigation can most readily do so in condition (a) because in this condition a smoke bank is very easily discerned and can nearly always be avoided by flying just to windward of the area causing it. (It should be remembered in this connection that when speaking of "calm conditions" I mean conditions in which the wind does not exceed three to seven miles per hour. It is comparatively rare to get an absolutely dead calm in this country). Under such conditions very remarkable comparisons may be experienced. To give a few examples: in a machine flying from London to Woodford I completed the course in brilliant sunshine and excellent visibility by keeping just to the east of Birmingham. Another pilot flying the direct route passed through a smoke bank nearly 40 miles in length to the west of Birmingham and over the Potteries and the air was so dark that he could hardly see to read his instruments. I have started a flight from Woodford in sunshine and in the neighbourhood of Barton, less than 15 miles away, I have found a fog so black that on descending into it one could see that motorists were using their headlights. On a flight from Woodford to Blackpool it is a common experience to meet a smoke bank to the west of the Belmont Moors so dense that the ground landmarks cannot be picked up. The belt is usually from 15 to 20 miles in length and is particularly bad in light westerly or south-westerly winds when it seems to be piled up against the hills. The same thing may be noticed when crossing the Pennines; according to whether the wind is east or west the pilot may start his

crossing in brilliant sunshine only to find a thick smoke belt waiting for him on the far slopes.

In really light air conditions it is remarkable how a smoke belt will travel as such. With a light wind from the south-east the smoke belt from Manchester and south-west Lancashire can be traced as a streamer right up to the western Solway and across towards Ireland. Actually such a belt has been traced over a distance of 200 miles by meteorological observers. With a similar very light wind the smoke from a cottage on the edge of Woodford aerodrome has spread across the aerodrome, forming a belt only a few feet deep but so dense as to make it necessary to suspend instruction in landing practice.

Whatever the meteorological conditions, clear or hazy, calm or windy, it is always noticeable that in and near the industrial areas the visibility is poorer. It would not be fair to blame this entirely on the smoke nuisance. The difference in temperature over the cities must itself tend to encourage condensation and the formation of water vapour. The hygroscopic nuclei which are necessary for the formation of fog must necessarily be present in the fumes rising from industrial areas in any case. Where, however, carbon particles are present in great numbers it is obvious that the density of any water vapour which may be formed must be increased and the visibility in such areas decrease. The point is of great importance to aircraft operators owing to the speed at which aircraft travel. To the landsman the smoke belt is perhaps an inconvenience rather than a danger. It pollutes the air which he breathes and greatly increases his laundry bill, but unless it becomes very dense it does not seriously impede his means of getting from one point to another. To a motorist the limitation of visibility to 800 or even 400 yards presents no obstacle. To the airman, travelling normally at from two to three miles a minute and with a minimum speed of perhaps one mile per minute or more, the obstacle is very serious. Visibility of only 400 to 800 yards makes it almost impossible for him to identify land marks and intensifies the risk of collision with some object attached to the ground if he attempts to fly low enough to pick up land marks.

It would be optimistic to imagine that a complete abatement of the smoke nuisance would entirely obviate the problem of poor visibility in the neighbourhood of industrial areas. On the other hand it is probably not too much to expect that it would halve the intensity of the problem. This would mean that in the areas where visibility at present averages half a mile it would be increased to a mile, which from the airman's point of view spells all the difference between comfort and discomfort and *may* spell the difference between safety and disaster.

VISIBILITY AND SMOKE IN RELATION TO AERIAL PHOTOGRAPHY.

By Captain ALFRED G. BUCKHAM, F.R.P.S.

On the envelopes of the communications I have received from this Society there is printed in red letters "Smokelessness is next to godliness." It set me wondering. I asked myself "Would the inhabitants of Stoke-on-Trent, for instance, the smokiest town in the British Isles, be only one step short of 'godliness' if relieved of their smoke cloud by the splendid efforts of this Society?" I sadly came to the conclusion, knowing many of the inhabitants of Stoke-on-Trent, that such a miracle is beyond the bounds of achievement. Doubtless then, I considered, the slogan possesses some other meaning, and this became apparent to me when I realized that three of the papers to be read at this Conference are provided by two distinguished pilots, and myself. Obviously that striking pronouncement was expressly conceived by its author for the benefit of ourselves; a reminder of what we may aspire to when the work of the Society is finally accomplished. Anyone who has listened to the language of an aerial photographer arriving over his scene of operations only to find it almost completely blotted out by drifting smoke, or that of his pilot who later on discovers that the aerodrome they started out from has in like manner disappeared from sight, will understand how much the activities of this Society mean to us in our strivings toward a higher and better life.

The great George Darwin once said, "It is better to observe than understand." A sage remark, to which I might add that, personally, I find it much easier that way; therefore, I largely confine myself to observation.

During twenty years' sky journeying as an aerial photographer the smoke of great cities and towns in thirty-four countries, and most of the States of America, has passed beneath my aeroplane; and of all the troubles encountered in the guise of regulations, officials, bad weather, antique aeroplanes, and pilots speaking the tongues of Babel, none have bothered me so much as the smoke fiend. But although I have flown day after day over towns in the Midlands seeing little of them but their canopies of smoke, I find that more incredible than the smoke is the complete indifference of their inhabitants to the injury inflicted upon them by its presence. Familiarity has produced an unthinking tolerance, or a sense of inevitability, which enables them to endure the infliction with the patience of Orientals bowing in submission to the Will of Allah. Not until these people are rendered really

"smoke conscious" will any great improvement take place; and to this end one might suggest that all the Gas and Electric Supply Companies throughout the country be invited to print upon their monthly or quarterly bills a few striking facts concerning the injury caused to health and property by the smoke nuisance, thus providing a cheap and constant means of propaganda. Apart from other considerations, and they are obvious, the Companies would be entirely compensated for their slight additional expenditure by thus diverting the attention of consumers from the amount of their charges.

From the skyway it is quite apparent that in Great Britain the chief output of smoke comes from private houses, particularly those situated in the poorest quarters, where inferior coals are burned in open grates and smoke is emitted from nearly every chimney. By self infliction thus to impose a smoke cloud upon the native miseries of vast manufacturing towns is a barbarous procedure, and a reproach to any civilized community. Should not particular attention be directed and concentrated upon them if the biggest end of the problem is to be solved? As one flies northward from London the vigour of the chimneys in performing their allotted function steadily grows greater, due, apparently, to the burning of softer coals. Possibly it will afford satisfaction to some Scotsmen to learn that Scottish chimneys far outdo Sassenach chimneys in volume of output, and long and sustained effort.

Scotland.

In early springtime on sunny, windless days, I have twice flown to Glasgow hoping to obtain aerial photographs of the city, only to discover it completely buried in smoke and a perfectly hopeless proposition from my point of view. Visibility was so poor to the leeward side of the city that a landing there would have been somewhat risky. Cruising around in brilliant sunshine, about half a mile up, I thought of the hospitals and clinics somewhere hidden down below, providing at considerable expense and trouble doses of artificial sunlight to sun-starved patients whilst the real, authentic thing was vainly struggling to get through to them.

I was once engaged in making a series of experiments with various plates and light filters to ascertain which combination provided the best means to penetrate through smoke haze. These were carried out over Leith in mid-winter from an altitude of 5,000 feet. The best results, although recording far more than was visible to the naked eye, failed to reveal any objects at all situated at ground level. They were smoke



PHOTOGRAPHS OF EDINBURGH

Capt. Alfred Buckham

submerged. But in photographs of the same area taken in July at 23,000 feet altitude, the doorsteps of the houses were recorded. Evidently the people of Leith breathe almost undiluted smoke during about four months of the year.

Before describing other experiences I should like to put forward for your consideration a theory which in my own mind has crystallized out into a fact, namely, that smoke fog is responsible not only for its own most objectionable presence, but that by imprisoning land fog or mist drifting in from the adjacent countryside, and so preventing its dispersal by evaporation, it greatly prolongs the period of fogs in built-up areas. Doubtless everyone, especially those living in suburbs nearest to the centre of great towns has noted that at first onset, and close to ground level, the fog is white or grey and composed of watery vapour, whilst overhead and at some low altitude the sky is a deep yellow denoting a ceiling of smoke spread over all. The foggy conditions having persisted for some time, the continuing emissions of smoke are forced downward by the heavier watery vapour, so that eventually the latter is sandwiched in between two belts of smoke fog. If my observations have led me to a right conclusion, then in largely abating the smoke nuisance you will at the same time rid the towns of those other unpleasantnesses of the atmosphere, dampness and humidity, which are an added burden to the townsman's life during the winter months, thus killing two birds with one stone. The photographs should assist in elucidating the foregoing theory.

Flying over Edinburgh on numerous occasions opportunities have been afforded me to observe the evolutions of the smoke fiend, for "Auld Reekie" provides him with a veritable playground. It will be observed in the first photograph, taken on a clear, sunny day in September when a moderate southerly wind was blowing, that the smoke is driven to lie in a belt beneath the rampart formed by Salisbury Crags and Arthur's Seat. With the wind continuing in that quarter the smoke layer remains constant there for days on end, and only a change in wind direction or an increase in its velocity to twenty or more miles an hour will carry it over the high barrier to the rearward. Should, however, the wind entirely fail the smoke pall gradually spreads over the entire city. If then a sea fog comes rolling in, a fairly frequent occurrence, it will pass beneath the smoke, which rises in great swathes, heaving, and sending out long fantastic streamers. They do not interfuse but remain separate and distinct, owing, presumably, to their widely differing densities. The second photograph of Edinburgh depicts the conditions prevailing on a windless day when the smoke haze rises over a thousand

feet. The remaining two were taken in clear weather with a strong breeze blowing the smoke before it, even so, there is considerable pollution of the atmosphere.

Flying southwards, Durham is seen to afford a striking example of the effects of water vapour and coal smoke, the mist arising from the river and the badly drained fields in the vicinity being nearly always present from October to March, and prevented, as I believe, from evaporating by the smoke shroud superimposed upon it. The Cathedral and Castle, as in the photograph, frequently stand out clear in sunshine, whilst the streets below are foggy and dark.

The Midlands and London.

Down through the manufacturing districts of the Midlands aerial photography is, in my experience, all but impossible during winter months, and usually difficult at all seasons of the year. Banks of smoke, alternating with drifts of dense, clammy vapour speed past the aeroplane, often blotting out the ground from view and constituting a menace even to highly skilled professional pilots who can generally be relied on to come safely through most adverse weather conditions. To the less experienced amateur pilots, whose numbers grow year by year, such conditions are fraught with danger. Casting one's mind back over years connected with flying one recalls many bad crashes attributable to poor visibility caused by smoke. An inspection of the photograph taken over Walthamstow will make plain how bad conditions may be; yet it should be borne in mind this records a very moderate display, for never having anticipated an occasion such as the present one my chief desire has always been to avoid smoke, not to photograph it. On this side of London, when winds blow between south and west, such scenes may be witnessed almost every morning soon after domestic fires are lighted during nearly six months of the year. Quite frequently, no landmarks are visible from the air where the smoke drifts out over the neighbouring fields, rendering it exceedingly difficult to discover the whereabouts of one's landing ground. Some few months' flying experience in this locality stand out in my memory like a bad nightmare, two of my friends being killed and myself badly shaken in crashes entirely due to this circumstance. The smoke often drifts across to Epping Forest where, unless moved on by a moderately strong breeze, it becomes arrested by the strata of cold, moist air lying over the Forest. By the simple experiment of wearing a light coloured suit and leaning against one of the forest trees in early springtime, it is possible to become adequately informed as to where some of London's smoke goes to in winter time.

Town Planning.

When flying over our large towns, and London in particular, it appears evident that lack of town planning contributes much to the smoke nuisance. Among a maze of narrow and tortuous streets, not a few of them ending in cul de sacs, and plainly evident through a pair of field glasses from the air, the smoke beats down in eddies and swirls and remains entrapped. In the U.S.A. the method of building in rectangular blocks with wide straight streets running through leaves few lurking places. From whichever quarter the wind may come it finds a direct and uninterrupted passage, driving the smoke before it. In New York, Pittsburg, or Philadelphia, one may see from an aeroplane, or a lofty skyscraper, great volumes of smoke proceeding from shipping on the rivers, or from utilities corporations, being hustled through the streets out into the open spaces beyond. Not less smoke is produced in these cities than in London, but it gets away better. New York, for instance, never experiences our "pea soup" variety of fog, yet in a recent report issued by the New York Academy of Medicine it is stated, "Smoke and soot deposit about four tons of solids each month on every square mile of the city's area and cause an average daily loss of light and health-giving rays of more than twenty per cent." A series of photographs of New York taken within a few minutes of each other show that although smoke abounds it does not linger in the streets among the buildings. Another factor assisting to mitigate the nuisance in American cities is that it proceeds chiefly from large manufacturing plants which disgorge their smoke at considerable heights from ground level where the wind blows free, whereas, in Great Britain, the chief offenders are domestic chimneys operating low down.

Unfortunately, aerodromes connected with passenger transport must be situated closely adjacent to the towns for the reason that air travel is usually chosen with the object of saving time. One of the most frequent complaints made by passengers is, however, that a considerable amount of time is wasted in getting to and from the airports, consequently we may anticipate that in the not distant future passenger aircraft will use aerodromes erected over railway stations, or other suitable places, in the very heart of the towns. The proposal is a practical one, and if carried out the smoke problem in relation to flying will certainly come up for very serious consideration.

It is not generally realized that smoke will assume cloud shapes indistinguishable from Nature's own beautiful formations in the sky; therefore it may be of interest to show a few photographs depicting this phenomena. The first

is a cloudscape taken over Epping Forest in December, immediately after a change in the weather had swept away a three day's fog from London city. The central black cloud, encompassed' about by billowy masses of vapour, was obviously chiefly composed of smoke, for I sampled its flavour when flying through it. Two more photographs taken in the course of the same flight, but nearer London and the river, largely owe their origin to smoke, while that of a smoke screen put up by aeroplanes of the U.S. Navy for fleet protection shows, quite distinctly, three tiers of cumulus shaped clouds built up on the sky line.

In conclusion, one cannot help regretting that this Conference is being held in the merry month of May when the domestic chimney ceases from troubling, and the poker is at rest. Had we groped our way hither through a choking November fog, and now were viewing each other as through a glass, darkly, our enthusiasm for smoke abatement would have gained added zest and even inspiration from the very atmosphere.

DISCUSSION.

The Chairman, Dr. DES VOEUX, President of the Society, in opening the proceedings, said that it was quite evident that aviation would increase at an enormous rate in the next ten years, and that any town which had no aviation centres would be left behind in the commercial race. Unless proper provision was made to make aviation safer than it was to-day other countries would win in the competition in the commercial world.

COUNCILLOR C. E. KEENE (Leicester Corporation) said that he wished to say a word in praise of Captain Buckham's photographs. He hoped that it might be possible for some arrangement to be made by which the Society could use such photographs at exhibitions. Similar photographs and other illustrations of the smoke nuisance should also be displayed in museums, where they would be seen by many people, especially children.

Mr. J. H. COSTE (Health Dept., L.C.C.) said that visibility observations taken from the tower of Westminster Hall corresponded with the degree of atmospheric impurity shown by the air filter. It could be said that the lower visibility in winter was due to seasonal change, but this was not necessarily so. He had on one occasion in winter noted that visibility in the Thames estuary was ten miles, while at the same time at Westminster it was only three-quarters of a mile. Thus it was clear that bad visibility in winter was essentially an urban feature.

If smoke was abolished completely the products of combustion of whatever fuels were used would still give rise to hygroscopic nuclei, and bad visibility in the places where fuel was burned. Even hot electric wires could create hygroscopic nuclei, and therefore there was bound to be poorer visibility where there were a large number of people. But none the less visibility would be improved by lessening smoke.

ALDERMAN E. F. M. SUTTON (Manchester Corporation) said that as Chairman of the Airport Committee of his Corporation he wished to correct misapprehensions about the Barton airport. It had not cost £100,000, but £45,000. Bad visibility was one factor for leaving, but it was not the main factor. The two main reasons for leaving were on account of obstructions—chimneys and pylons—and on account of small runways. The longest was only 650 yards instead of the 1,200 or 1,500 yards required to-day. To extend the runways would cost an enormous sum owing to the bad, almost boglike, condition of the land.

In reply to one suggestion made he could say that there would not be factories at Ringway. Any such work could be done at Barton. Houses built round the Ringway aerodrome would be

controlled by zoning. Tests at Ringway had shown that visibility there was much better than at Barton.

Mr. STEPHEN B. CLIFF asked Captain Buckham if his photographs, in spite of the conditions they disclosed, were not actually taken in conditions of good visibility. If visibility had been poor he thought they would not have come out at all.

ALDERMAN G. F. TITT (Manchester Corporation) referred to the smoke question in Manchester, and said that the industrial problem had largely been solved. The city suffered chiefly from the smoke of surrounding districts that had not controlled industrial smoke so effectively.

Mr. S. B. CHANDLER (Institution of Gas Engineers) referred to the need to use other methods in place of raw coal, which was the source of the whole trouble.

Mr. W. PHILLIPS (Luton Gas Company) asked Mr. Durst if there was any evidence that smoke particles in the atmosphere had any effect upon icing conditions during flying.

Dr. R. LESSING said that as a member of the Society he wished to voice satisfaction of the way in which the speakers had presented their papers. The effect that smoke had upon aviation was a new plea for smoke abatement, and should be used because; though the effect of smoke upon health should be sufficient to stir the conscience of the country, it had not done so. The papers that had been read showed that smoke was detrimental to the welfare of the whole nation. It was a new weapon for smoke abatement, and if the progress of aerial transport was to continue, something would have to be done to reduce the danger of bad visibility. He urged that the evidence should be used as much as possible.

Dr. J. JOHNSTONE JERVIS (Medical Officer of Health, Leeds) suggested that the membership of the National Smoke Abatement Society should benefit as a result of the meeting. Every air organization should support the Society, for they were as interested as the Society in the abatement of smoke. And airmen, too, could help by making their homes smokeless.

Mr. ELLIS asked the speakers if there was any collected evidence as to the extent to which accidents to aircraft had occurred as a result of bad visibility due to smoke. He also asked Mr. Durst if there were variations of visibility in London in different localities.

Mr. DURST, in reply to Mr. Coste, said that with regard to visibility in winter at Westminster Hall compared with the mouth of the Thames, one should not correlate visibility at a land station with that of a sea station. Visibility at sea was due to different

conditions, and in Table I of his paper it would be seen that at Scilly at 0700 hours fog is worse in the summer than in the winter. The same conditions were also found at Aberdeen, another station on the sea.

In reply to Mr. Phillips, he said that as far as was known smoke particles could have no effect upon ice formation.

In reply to Mr. Ellis, he said that variations of visibility in the London area were considerable.

Mr. GOODFELLOW, in replying to the discussion, pointed out that visibility would still be worse over urban than over rural areas, but that smoke abatement would mean the range of visibility over towns would be increased, and would therefore increase safety.

With regard to ice formation he explained that this would not occur below a certain height, and therefore in order to avoid it a flyer would have to travel low, but in doing so might find himself in difficulties through being in the layer of smoke.

He was glad to know that factories would not be built around the Ringway airport, but the houses on the Wythenshawe estate already had an effect upon visibility in that area, in spite of the fact that they had only one coal fire. The estate lay on the line between Barton and Woodford aerodromes, and it was always to be noticed as an area of poor visibility.

He did not know what the accidents statistics would be for this country, but, quoting from memory, he believed that 10 per cent of the accidents in America were due to lack of visibility.

CAPTAIN BUCKHAM, in reply, said that all the photographs were taken on days of good visibility, and on days of poor visibility they would have shown hardly anything at all.

Mr. COURTENAY said that he was afraid it would be difficult to avoid the erection of factories around aerodromes. When a municipality constructed an aerodrome it wanted revenue to repay it for its expenditure, and one way of doing this was by offering sites round the aerodrome, for aircraft works especially. The Air Force expansion and the growth of civil aviation meant that shortly every aircraft company would be working at full pressure and would be seeking new sites and testing grounds.

FFC

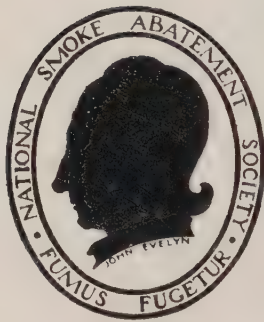
Dr. DES VOEUX, at the end of the discussion, moved the following Resolution on behalf of the Council of the Society:

“THAT copies of the papers submitted to this Conference be forwarded to the Minister of Health and Minister of Air with

letters drawing their attention to the serious statements made by the authors of those papers as to the extent to which aviation is interfered with by smoke and especially by smoke emitted from aggregations of private dwellinghouses, and that this Conference expresses the view that in connection with all new Municipal or other Housing Schemes the Local Authorities concerned should be urged to adopt more effective measures to provide smokeless means of cooking and heating."

This was seconded, and carried unanimously. A hearty vote of thanks to the four speakers for their valuable papers was proposed by the Chairman, and was carried with acclamation.

A vote of thanks to the Chairman was proposed by Sir Lawrence Chubb and similarly carried, after which the meeting was closed.



~~106~~ (06)



NATIONAL SMOKE ABATEMENT SOCIETY

please return to:-

NATIONAL

SOCIETY FOR CLEAN AIR

134/137 NORTH STREET

BRIGHTON, BN1 1RG

Proceedings

of the

Conference

held at the

SCIENCE MUSEUM, SOUTH KENSINGTON

October, 1936

Price: TWO SHILLINGS

**36 KING STREET
MANCHESTER, 2**

PROCEEDINGS of the
8th ANNUAL CONFERENCE
National Smoke Abatement Society
 held at the
SCIENCE MUSEUM, SOUTH KENSINGTON,
 on
14th, 15th and 16th October, 1936

CONTENTS.

FIRST SESSION.

- Opening Address by Captain Harry Crookshank, M.P., Secretary for Mines ... 3
- A Review of Methods for the Prevention of Grit and Dust Emission, especially
 from Pulverized Fuel Furnaces, by A. T. Barber and T. F. Hurley. ... 4

SECOND SESSION.

- Modern Methods of Dealing with Smoke Prevention Problems in the Iron and
 Steel Industry, by H. C. Armstrong ... 23
- The Problems of Smoke Emission in the Clay Industries, by E. Rowden and
 A. T. Green ... 31

THIRD SESSION.

- The Solution of the Domestic Smoke Problem, by Dr. Margaret Fishenden ... 52
- "Through a Glass Darkly," by Noel Carrington ... 63

FOURTH SESSION.

- The Effect of Atmospheric Pollution on Vegetation, by Dr. C. R. Metcalfe and
 Sir Arthur W. Hill ... 67
- Developments in the Investigation of Atmospheric Pollution, by Dr. J. S. Owens 74

FIFTH SESSION.

- Atmospheric Pollution in Relation to Tuberculosis, by Sir Pendrill Varrier-Jones 82
- Light and Clean Air in Relation to Surgical Tuberculosis, by Sir Henry Gauvain 89
- The Obstruction of Light by Smoke and Its Effect on Health, by Sir Leonard Hill 94

SIXTH SESSION.

- Public Health Administration and Smoke Abatement, by Dr. A. S. M. Macgregor 100
- Smoke and the Sanitary Inspector, by H. G. Clinch ... 108

First Session, Wednesday, 14th October, 11-15 p.m.

THE OPENING OF THE CONFERENCE BY THE SECRETARY OF MINES,

Captain Harry Crookshank, M.P.

(Chairman: Dr. H. A. Des Voeux).

CAPTAIN CROOKSHANK said that the National Smoke Abatement Society organized the Exhibition to show to the public the benefits of smoke abatement and the methods by which smoke could be prevented. The Exhibition was one of the most interesting displays he had ever seen.

It was an honour to the Society that the Minister of Health should have opened the Exhibition, and it was clear that there was a close relationship between smoke abatement and health. One of the main objects of the Society should be to bring before the public the importance of smoke abatement in respect to health, for the effects, and also the effects upon vegetation, were serious, and we could not afford to ignore them.

A great deal of consideration had been given to the efficient running of industrial plant, and it was now generally known that excessive smoke could be avoided by reasonable means. Attention had been given in particular to the larger industrial plant, but it was the smaller plant that required improvement, and for this co-operation was needed more than administration.

The Society was helping greatly to reduce the smoke nuisance by urging the use of the best methods, by giving information, and by drawing attention to the evil. In urging smoke abatement they must be careful not to condemn the use of coal, and he believed that it was not the intention of the Society to seek to reduce the use of coal. If it was he would not have been there that morning. In removing one social evil, it was undesirable to create another or to aggravate an existing social problem such as already exists in the depressed coal districts. With his interest in the coal industry his policy in regard to the use of fuels had been to give the domestic consumer freedom of choice. The English tradition was in favour of the open fire, and this should be preserved.

The Society, continued Captain Crookshank, wished to be practical, and therefore it must, first, remember the importance of the domestic fire to the coal industry, and second, should do what it could to improve the conditions under which coal was used. Many of the appliances in use were inefficient, and one aim of the Society should be to indicate to the public where the trouble lay. He referred to the Coal Utilisation Council and the work it was doing in this respect in co-operation with the Fuel Research Board.

A great deal of good could be done by the co-operation of the chief fuel industries, including the coal industry. Great strides could be made in the direction of cleaner cities and clean air, and this should be done without causing any harm to the coal industry.

Captain Crookshank concluded his address by declaring the Conference open, and giving it the following message: "Go ahead with the work you are doing."

A REVIEW OF METHODS FOR THE PREVENTION OF GRIT AND DUST EMISSION, ESPECIALLY FROM PULVERISED FUEL FURNACES.

By A. T. BARBER, B.Sc., M.I.Mech.E., and

T. F. HURLEY, B.Sc., A.M.Inst.C.E., A.C.G.I.

(Of the Fuel Research Station).

The problem which is engaging the attention of this Conference is a very extensive and complicated one in view of the very diverse nature of the purposes for which coal is burnt as a fuel. The figure given in Table 1 of the quantities of coal consumed annually under various sections, although giving no indication of the relative pollution actually involved, do, however, serve to shew the relative amount of attention that should be paid by each section to the avoidance of harmful emissions.

The case of the domestic chimney, though not coming immediately into this review, requires a brief consideration. In this case the pollution, by no means inconsiderable in amount, is practically entirely caused by soot—finely divided carbon together with tarry matter—a product of the imperfect combustion of soft bituminous coals. While the ultimate cure of this evil may necessitate legislation to prohibit the use of such coals for domestic purposes, the problem is slowly solving itself by the increasing use of electricity, gas, coke and other smokeless fuels for domestic heating or cooking.

In the case of industrial chimneys generally, the dust emitted may comprise (*a*), soot, including tarry matter; (*b*) fly-ash or grits from the fuel bed itself, consisting of particles of coal ash and partially carbonized coal; and (*c*) dust from the materials being treated. Sulphurous constituents are not considered in this connection, since although many of the methods used for dust removal are ineffective to remove sulphur impurities, any process devised primarily for sulphur removal will result in efficient dust removal.

The quantities of each of the various types of dust emitted from any particular furnace may to some extent be regulated by the method of operating the furnace, and in most cases careful attention to the design, maintenance and operation of the furnace and its auxiliaries will result in a material reduction of the amounts of dust emitted. Thus careful attention to combustion conditions should result in the elimination of soot from such as boiler chimneys, while even where strongly reducing atmospheres are required, such as in brick and pottery kilns, a clear stack should be possible by modifying the design of the furnace and method of firing. Nevertheless, even when the furnaces are well-designed and carefully operated to give the conditions necessary for the successful conduct of the particular process, a certain amount of dust emission is unavoidable, and means must be provided to clean the furnace gases before discharge to the atmosphere, unless we are to admit that progressive pollution of the atmosphere is a legitimate and necessary concomitant of industrial development.

In some industrial processes the dust derived from the materials being treated may be of sufficient value in itself to make the trapping of it an economic as well as a considerate proposition, e.g. dryers, roasting kilns and metallurgical furnaces, but in the case of boiler furnaces, no such inducement is offered and the collection of dust from boiler flue gases is an expensive necessity entailing extra capital outlay for plant and increased costs for power and maintenance.

The amount and nature of the dust present in boiler gases naturally varies considerably with the type and design of furnace, draught and load conditions and the characteristics of the coal burnt. It will at once be evident that the percentage of ash in the coal will directly affect the quantity of flue dust in the gases, while among coals of equal ash content that having an ash of high fusion point will produce more dust than one having ash of lower fusing temperature, since in the latter case the fused ash remains on the grate as clinker. The emission of dust from boiler stacks is therefore to some extent preventable by the use of cleaned coals. The necessity for cleaning coal of all grades is becoming more and more recognized, and as the demand increases and the

price margin between clean and dirty coal diminishes, the use of clean coal becomes still more economical on all grounds. In fact it is worth while carefully to consider how far the expense of providing and maintaining dust collecting apparatus may be obviated by the use of clean coal in place of some of the so-called cheap fuels. In addition to reducing the amount of ash, the cleaning of coal in many cases effects a considerable reduction in the sulphur content, and so reduces the contamination from this cause when the coal is burnt.

The physical properties of the solid particles as well as the degree of concentration in the gases must be taken into account in deciding on the most suitable type of dust collecting apparatus to be installed for any given plant. The principal properties affecting collection are (1) size, (2) density, (3) wetting, (4) ionization.

The range of particle sizes may be from large grits of say $\frac{1}{8}$ in. diameter down to very fine dust of less than 10μ , covering the comparatively coarse grits emitted from stoker-fired furnaces to the extremely fine dust from pulverised coal furnaces. The rate of settlement of the dust is dependent on the size and density of the particles, being proportional to the square of the linear dimensions and to the density of the material.

The settling rate determines the degree of nuisance caused, since neglecting the effect of wind velocity, the larger and denser particles will be deposited close to the chimney while the finer and lighter particles will be carried a greater distance. With an increase in wind velocity or with a lofty chimney the area of distribution will be extended without changing the order of settlement. Thus a domestic chimney may become a relatively greater nuisance in its immediate neighbourhood than a tall factory chimney.

These factors are made use of in all types of dry dust collectors, but since in most cases the natural settling rate is extremely low, the settlement can be very considerably accelerated by making use of centrifugal force. By causing the dust laden gases to follow a circular or helical path the force acting on a dust particle and tending to force it out of the stream is inversely proportional to the radius of curvature of the stream. So that as the radius of curvature of a straight path may be taken as infinity, a centrifugal collector of any practicable radius will give an enormously increased separating effect. The problem in this type of collector is chiefly in arranging the discharges of dust and cleaned gases so as not to cause interference and re-entanglement of the separated particles, and in producing a satisfactory compromise between size of plant and the power required to give the required velocity to the gases.

Flue dusts generally are extremely resistant to wetting by liquids, and collecting plants employing wet methods depend for their efficiency on the dust particles becoming attached to the surface of a film of water or to the water particles in a spray. The quantity of water used in these plants is necessarily very great and the separated dust is discharged from the plant in the form of a very thin slurry, which requires treatment by filtration or sedimentation if the water is required for recirculation or before discharge to rivers or sewers.

Dust collection by electrical methods depends on the capability of the dust particles becoming electrically charged or ionized when a high electric potential is applied across the gas stream. The charged particles are then attracted to the earthed electrode (plate or tube) to which they adhere until caused to fall into the receiving hopper by rapping.

Mention has already been made of the fusion of the bulk of the coal ash in furnaces fired with lump coal, whereby the major part of the ash remains in the furnace and can be removed in mass by hand or mechanical means. A similar method has been applied to pulverized coal furnaces, in a type known as the "slag-tap" where the furnace conditions are regulated so as to agglomerate and fuse the fine ash particles which are ultimately drawn off as a fluid slag. This method involves a specially constructed furnace and is therefore perhaps an example of furnace design rather than a method of collection applied to a plant layout.

Methods of Dust Collection.

The various types of apparatus for the removal of dust from flue gases may be grouped according to the fundamental principles upon which they are designed, but this grouping is very arbitrary and not only may one type be used in series with another but two or more methods may be employed simultaneously in the same apparatus.

The first obvious division is into dry and wet types. In the former the dust is deposited dry whereas in the latter it is first wetted and finally removed as a slurry. The dry types may be sub-divided into three groups (a) those making use of gravity alone; (b) those using centrifugal force, and (c) the electrostatic type.

The wet types include those in which the gases are brought into contact with water which may be in the form either of a film or of a spray, and may, or may not, be recirculated through the system after the removal of the dust.

Dry Types.

Settling Chambers.

The simplest form of dust separating apparatus consists merely of a large chamber in which the solid particles settle under the action of gravity. As shown above in the absence of turbulence each particle, if allowed to fall freely, will tend to fall at its terminal velocity

$$v = \frac{2}{9} \frac{a^2 \rho}{\eta} g$$

where a is the radius and ρ the density of the particle and η the viscosity of the gas.

From this equation it is apparent that as the velocity of fall depends upon the square of the radius, the size of the particle has an important influence upon the time it will take to fall through a given distance. Thus a 60μ particle will take 1.36 seconds to fall through a distance of one foot, whereas a 10μ particle will take 49.0 seconds.

The time of passage of the gas through the chamber is equal to the volume of the chamber divided by the volume of flue gas leaving the boiler per second, and as the latter term is always relatively large, even with a small boiler, the time available for settling is inadequate for small particles in a chamber of reasonable size. Thus with a Lancashire boiler generating 10,000 lbs. of steam per hour, the time taken by the products of combustion to pass through a chamber 20 ft. long and 10 ft. by 10 ft. in section, is only 25 seconds against 490 seconds required for a 10μ particle to fall 10 ft.

It is evident, therefore, that settling chambers can be considered as a practicable form of dust separator only when dealing with relatively large and dense particles, and in very small installations.

Many methods of reducing the disadvantage of size, which is inevitable with a plain settling chamber, have been employed with varying success. One method is to insert horizontal partitions so arranged that the maximum distance a particle has to fall is the distance between the partitions instead of the full height of the chamber, but this method involves a certain amount of difficulty in removing the deposited dust. In other cases baffles are inserted in the chamber in such a manner as to cause numerous changes of velocity and direction which materially assist in the deposition of dust. Yet another method, sometimes combined with the last, is to fill the chamber with a fine mist of water or wet steam which adheres to the particles and so increases their effective size and ease of deposition. This has certain disadvantages which will be discussed later in connection with wet methods of washing, but it is, in various forms, extensively used for both large and small boiler plants.

Centrifugal Separators.

The size of a dust collecting apparatus can be materially reduced if the velocity with which the dust particles cross the stream lines of the gas, i.e. the falling velocity in the case of a plain settling chamber, can be increased. One method of doing this is by the use of centrifugal force.

If the gases carrying the dust travel in a circular path there will be a radial force F acting on each particle such that

$$F = m \frac{dv}{dt} = \frac{4}{3} \pi \frac{a^3 v^2 \rho}{r} - 6 \pi a \eta v$$

where V = the circumferential velocity of the particles and r the radius of curvature of their path. Then the maximum radial velocity, i.e. the maximum rate of separation of the dust and the gas occurs when

$$v = \frac{2}{9} \frac{a^2 v^2 \rho}{r \eta}$$

From this equation the advantages and limitation of centrifugal separators are at once apparent. As with the settling chamber, efficiency depends upon the term a^2 and is thus seriously reduced as the size of the particles is reduced. On the other hand, g is replaced by the term $\frac{V^2}{r}$ and this can easily be made many times the force of gravity.

There is, however, a limit to which centrifugal force may be exploited and this is set by the fact that in order to obtain a very high value for V it is necessary to employ fan power and beyond a certain point, dependent upon circumstances, this may become too expensive as regards power, pressure drops, and capital and maintenance costs.

In much the same way the term r may become important. The smaller it is then the more efficient will be the separation obtained and conversely, the larger the separator the less efficient will it be. There is thus a practical limit to the size to which a simple centrifugal separating unit may be built and it is therefore quite usual for several separators to be used in parallel. This has the additional advantage that by cutting out one or more units, the capacity of the collecting plant may be varied according to the load on the boiler without sacrifice of efficiency.

In its simplest form a centrifugal separator consists of a chamber in which the gases are given one or more changes of direction either by means of baffles or by the arrangement of the ducts at entry and exit. Such collectors are usually suitable only for relatively large or heavy particles, e.g. the "grits" from small hand-fired furnaces, but within their limitations they are often of genuine utility. As a rule, the velocity of the gases through them is small and such that they can be used without the expense and complication of fan power.

The most common type of separator where a pressure drop, which may be of the order of $1\frac{3}{4}$ to $2\frac{1}{4}$ in. water gauge, is permissible, is the well-known cyclone. In its simplest form (Fig. 1) this consists of a short cylinder which the gas enters tangentially and leaves through a central opening, generally fitted with an internal "skirt." At the base of the cylinder is an inverted cone at the bottom of which is some form of valve through which the dust collected can be removed.

As a result of the present demand for higher efficiencies of dust separation, having regard to both the quantity and the fineness of the dust removed, many modifications have been made in the design of cyclones and for some of them extraordinarily high figures are quoted.

Fig. 2 illustrates a modern type of cyclone similar to that used at many power stations, including some working with powdered fuel. In a typical installation 12 such cyclones are fitted to one large boiler with one induced draught fan for each 6 cyclones. Arrangements are made whereby the number of cyclones in use can be adjusted to suit the boiler load and maintain the inlet velocity to the cyclones at about 30 to 40 feet per second. To minimize the abrasive effect of the dust upon the fan parts, the fan is fitted at the outlet side.

In the type illustrated the cylindrical top of the simple cyclone is replaced by a volute chamber so arranged that the gases follow a path of decreasing radius, the efficiency of separation thus being greater at the end than at the start of the volute.

Next, the conical base of the normal cyclone is replaced by a series of cylinders and truncated cones. For this arrangement various claims have been put forward, e.g. it increases the time the dust particles are under the action of centrifugal force; it enables gravity to assist separation; it lengthens the vortex within the cyclone and so decreases the effect upon the particles of the radial inward flow of the gases without decreasing the centrifugal actions; it causes the gases to take a short upward turn at the base of the cyclone, thus giving an additional precipitating action, and so on. Finally, a collecting chamber is fitted at the base of the cyclone so arranged that it can be emptied without breaking the vacuum in the centre of the vortex and, still more important, allowing the cyclone to be run empty without any tendency for the dust to be picked up again by the gases after it has once been deposited.

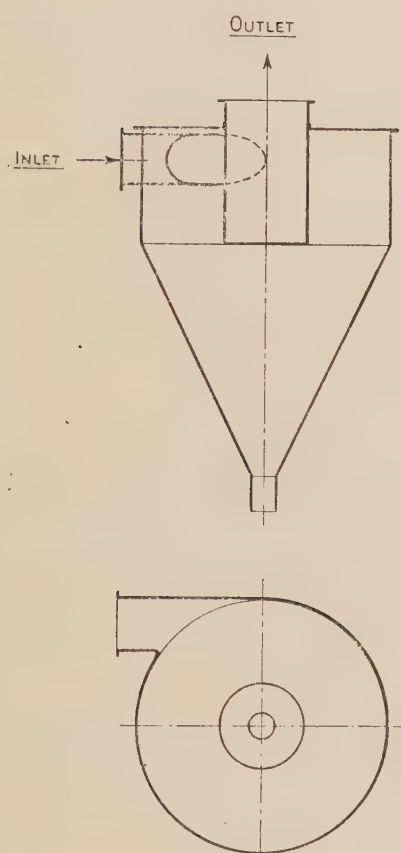


Fig. 1



Fig. 2

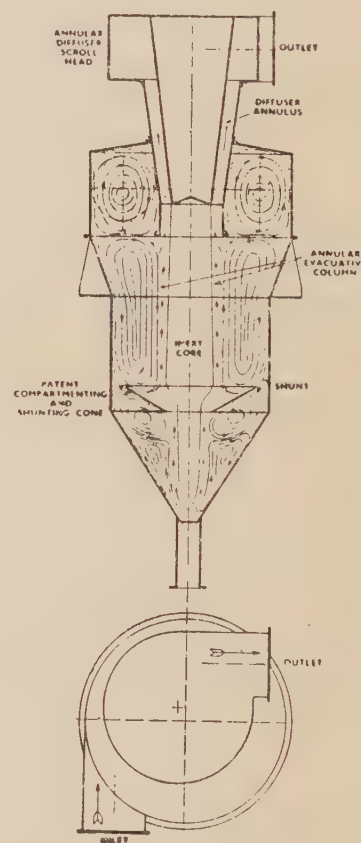


Fig. 3

A second modification of the cyclone is shown in Fig. 3. Here again the bottom cone is elongated but not reduced in diameter to the same extent as in the last example. A collecting chamber is again arranged at the base, but in this case it is separated from the main body of the cyclone by a conical baffle with a central opening and clearance between the baffle and the shell. It is claimed that both in the main body of the cyclone and in the collecting chamber, the gas flow is in the form of double vortex rings which accentuate precipitation, but this claim is not peculiar to this particular type. It will also be noticed that the outlet is arranged as a scroll in order to convert part of the kinetic energy in the whirling gases into pressure energy and so reduce the pressure drop as measured over the whole system.

In yet another form of cyclone, Fig. 4, the gases find their way to the central outlet through a series of vertical louvres so arranged that in order to enter the louvres

they must undergo a sharp change of direction. This, of course, has the effect of decreasing r in the equation, and should tend materially to assist separation. In this application, as in several others, part of the gases are bled off from the periphery of the main separating chamber at the point where the dust is most concentrated and are led to a much smaller cyclone where the final separation takes place.

A more definite departure from the cyclone, while yet retaining the centrifugal effect, is made in certain types of separator where the gases are constrained to follow a spiral path, thus forcing the dust to the periphery whence it is drawn off either by means of a tongue or through a suitable slot, as shown in Figs. 5 and 6. The small quantity of air accompanying the dust is then separated either by simple settling or by a relatively small centrifugal device. In such cases care must be taken in balancing the pressures throughout the system and in returning the cleaned gases from the final collecting chamber to the stack.

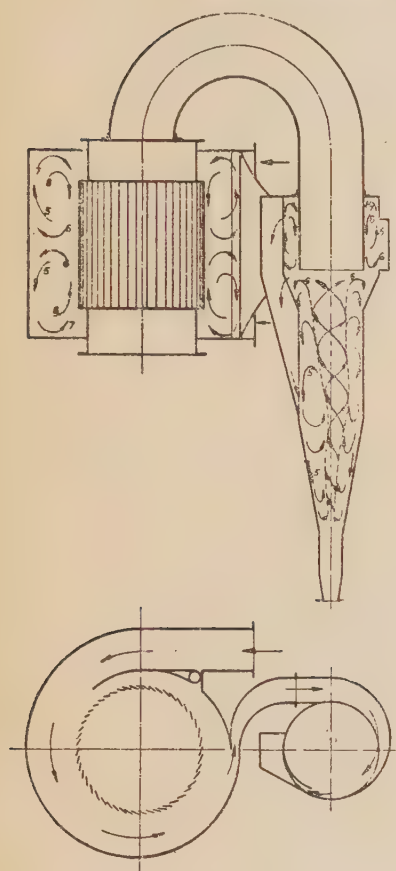


Fig. 4

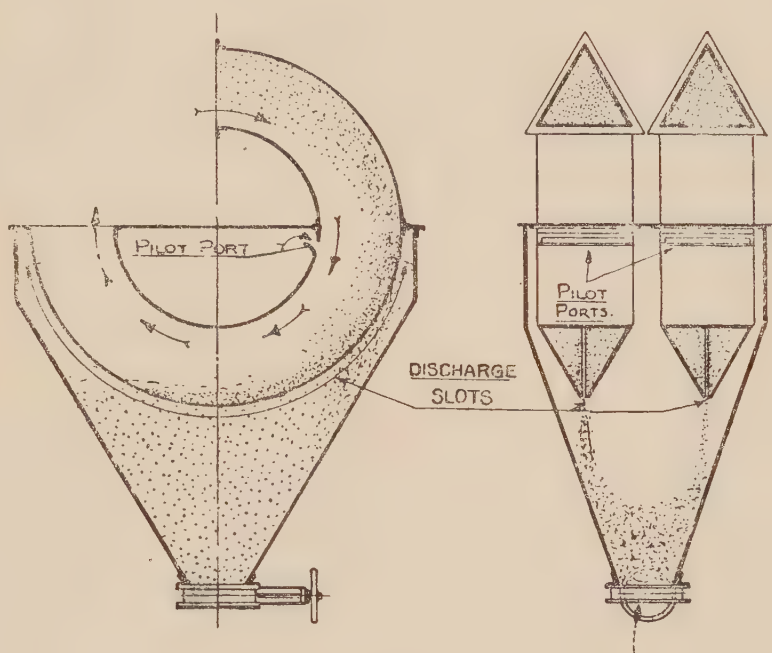


Fig. 5

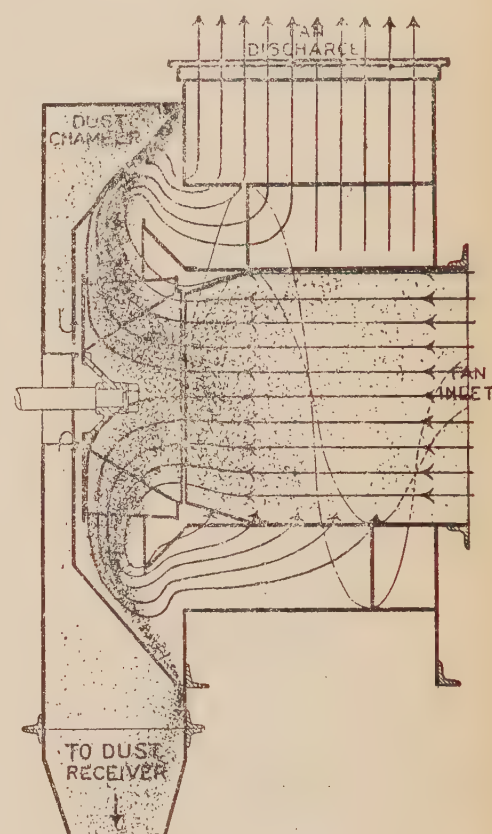


Fig. 6

Considerable ingenuity has been used in designing these and similar devices in saving space, e.g. by incorporating the fan in the separator, in avoiding abrasion, e.g. by arranging that only clean gases pass through the fan, and in such details as the method of removing the concentrated dust from the primary separator. They are, however, all subject to limitations as regards minimum size of particle, maximum size of unit and maximum practicable velocity as are all centrifugal methods.

It has already been shown that the smaller the radius of curvature of the path taken by the gases the greater will be the separating effect. In the two dust collecting plants illustrated in Figs. 7 and 8, advantage is taken of this property by inserting in a chamber through which the gases pass horizontally, specially long vertical baffles in such manner as to give rise to a large number of small swirls or changes of direction. Suitable provision is made for tapping off the dust collected by each element into a settling chamber below the main collector and for returning the dust free air from the settling chamber without upsetting the pressure balance through the system.

Electrostatic Precipitators.

During recent years, particularly since the advent of pulverized fuel and the extremely fine flue dust associated with it, another type of dry separating plant has

become increasingly prominent, viz.: the electrostatic type. This has the great advantage that it is practically non-selective as regards size of particle, i.e. it will remove very small particles at least as easily as large ones. In principle the method consists of passing the dust laden gases between two electrodes, one of which is charged to a high negative potential and the other earthed. As a result of ionic discharge between the electrodes the dust particles become charged and in consequence move towards the positive electrode where they are discharged and collected. Obviously the velocity of the gases through the system, the distance the particle has to travel, and the voltage used must be so correlated that a particle can travel from one electrode to the other during the time the gases are between the electrodes.

The main variation in the construction of different electrostatic precipitators usually lies in the design of the electrodes, which, indeed, vary from plant to plant when made by the same firm. In one case the earthed or collecting electrodes are formed as tubes usually some 6 to 10 inches in diameter and from 10 to 14 feet long, which may be hexagonal for convenience of their construction in groups. The negative electrodes then take the form of wires which may be of square cross section in order to assist the ionic discharge and which are suspended from suitable insulators so as to hang centrally down the tubes. The wires are weighted to keep them taut and the weights are inter-connected in such a way as to reduce any tendency for them to sway.

In other arrangements the electrodes take the form of sets of parallel plates and the discharge is assisted by points or other sharp projections upon the surface of the negative electrodes.

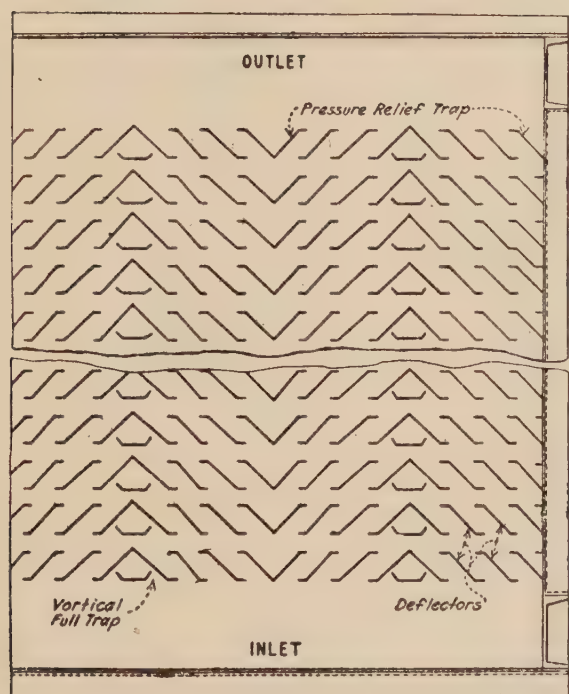


Fig. 7 (Plan)

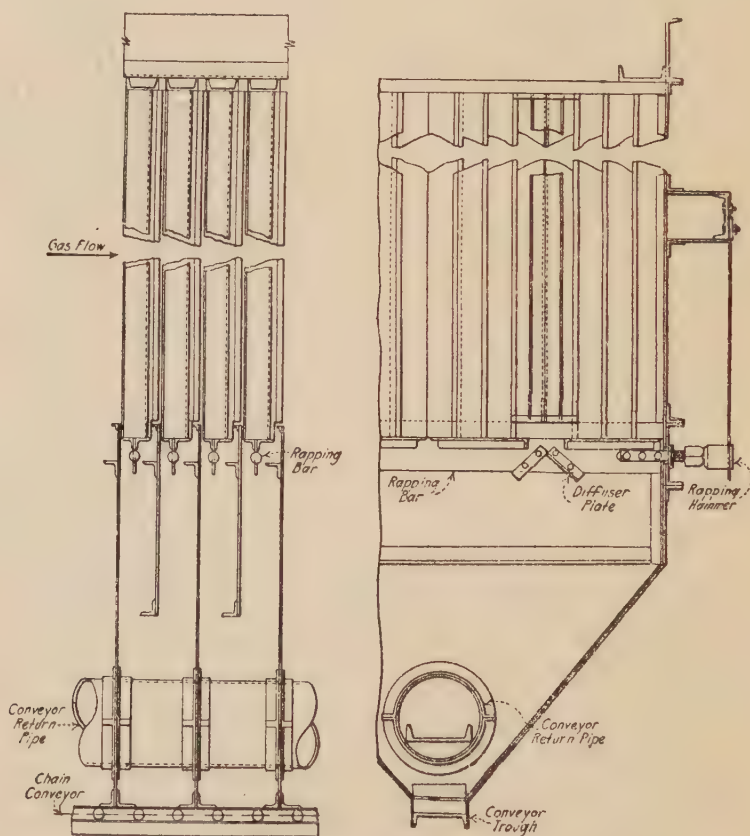


Fig. 7 (Elevation)

In all cases it is necessary to fit some form of rapping gear in order to shake dust from the electrodes down into collecting hoppers built into the base of the plant. As in some plants the gases flow upwards between the electrodes, the dust then has to fall against the gas flow. It is, however, claimed that it falls from the electrode in the form of loosely knit aggregates which are too large to be carried by the gas, particularly in the neighbourhood of the walls where the velocity of gas flow is a minimum. Nevertheless, in some plants pockets are provided in the collector electrodes to receive the dust and lead it into internal passages formed between the electrodes to allow the dust

to fall into the hoppers out of contact with the gas. The removal of the deposited dust from the receiving hoppers presents little difficulty, although it is advisable to avoid any tendency for it to be so agitated that it is again picked up by the gas flow. Two typical electrostatic dust precipitators are shown in Figs. 9 and 10.

The power required by an electrostatic precipitator is very small and the electrical apparatus, in spite of the high voltage, is remarkably simple. One arrangement is to step up the voltage of a single phase A/C current in a suitable transformer and to rectify it by a mechanical rectifier consisting of a simple form of commutator driven by a synchronous motor. There is, of course, always an element of danger with extremely high voltages, but this can be reduced to negligible proportions by suitable mechanical and electrical interlocking devices in both the generating house and the precipitator itself.

At one time the design and construction of insulators to work at high voltages in possible contact with hot dirty gases presented some difficulty, but it is understood that this has now been successfully overcome.

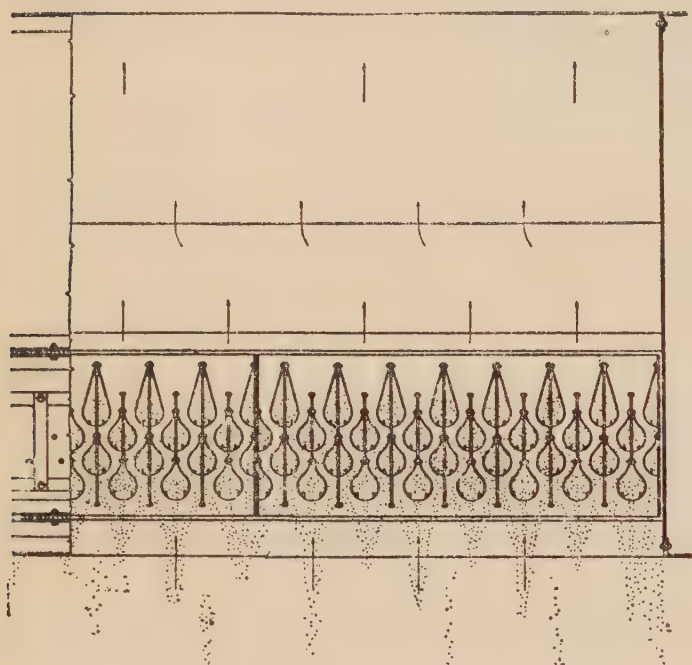


Fig. 8

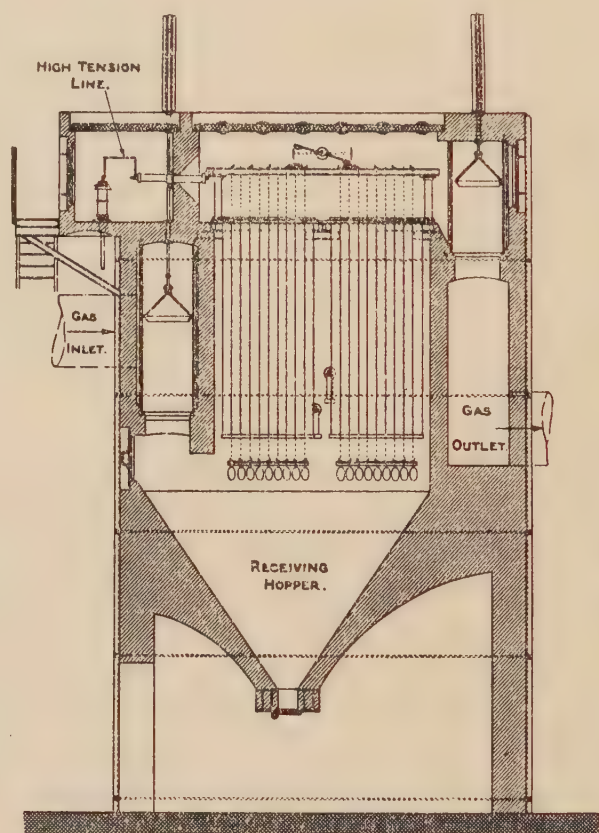


Fig. 9

As has been indicated above by far the principal advantage of the electrostatic type of dust extraction plant is that it can deal with all sizes of dust, and in particular with the very fine flue dust associated with pulverized fuel firing. Very high efficiencies indeed can be obtained, although, as with all plants, the efficiency falls off after a certain load has been reached, and at the upper limit small increases of efficiency tend to become expensive. Other advantages are that high gas velocities are not necessary—indeed, they are undesirable—and therefore the pressure drop through the system is low, say $\frac{1}{4}$ in. water gauge, and fan costs are proportionately reduced. Both power and maintenance costs are low and, as in most dry systems, the temperature drop through the plant is low and does not seriously affect chimney draught.

There are, of course, various disadvantages such as the space occupied by the collector and auxiliary gear, the use of high voltages and particularly in early installations possible weaknesses in the design of certain features such as insulators, rapping gear, etc. These, however, are all insignificant compared with one outstanding disadvantage in relation to other dry separators, and that is high capital cost,

Wet Types.

In considering alternative methods of cleaning flue gases the dry types have one disadvantage which in certain cases completely precludes their use and makes the

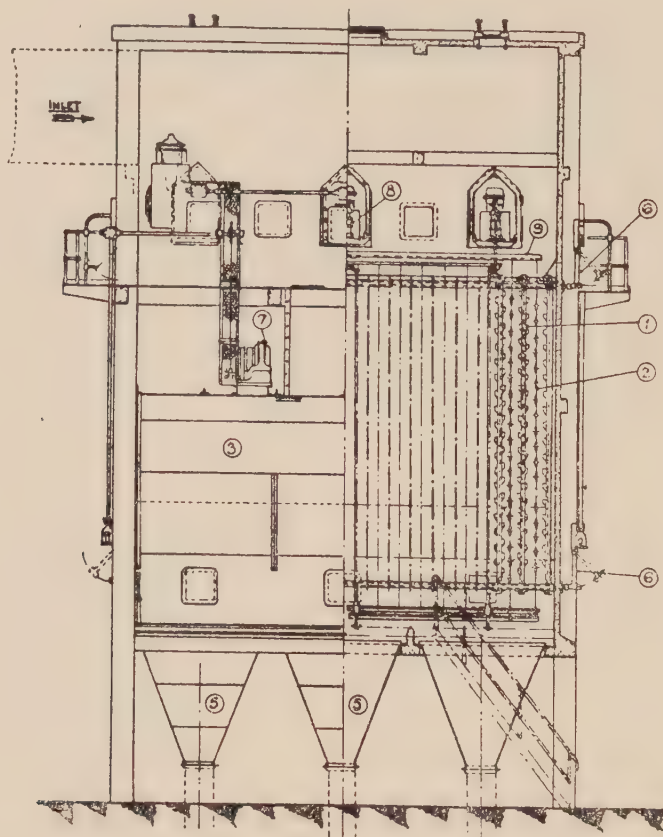


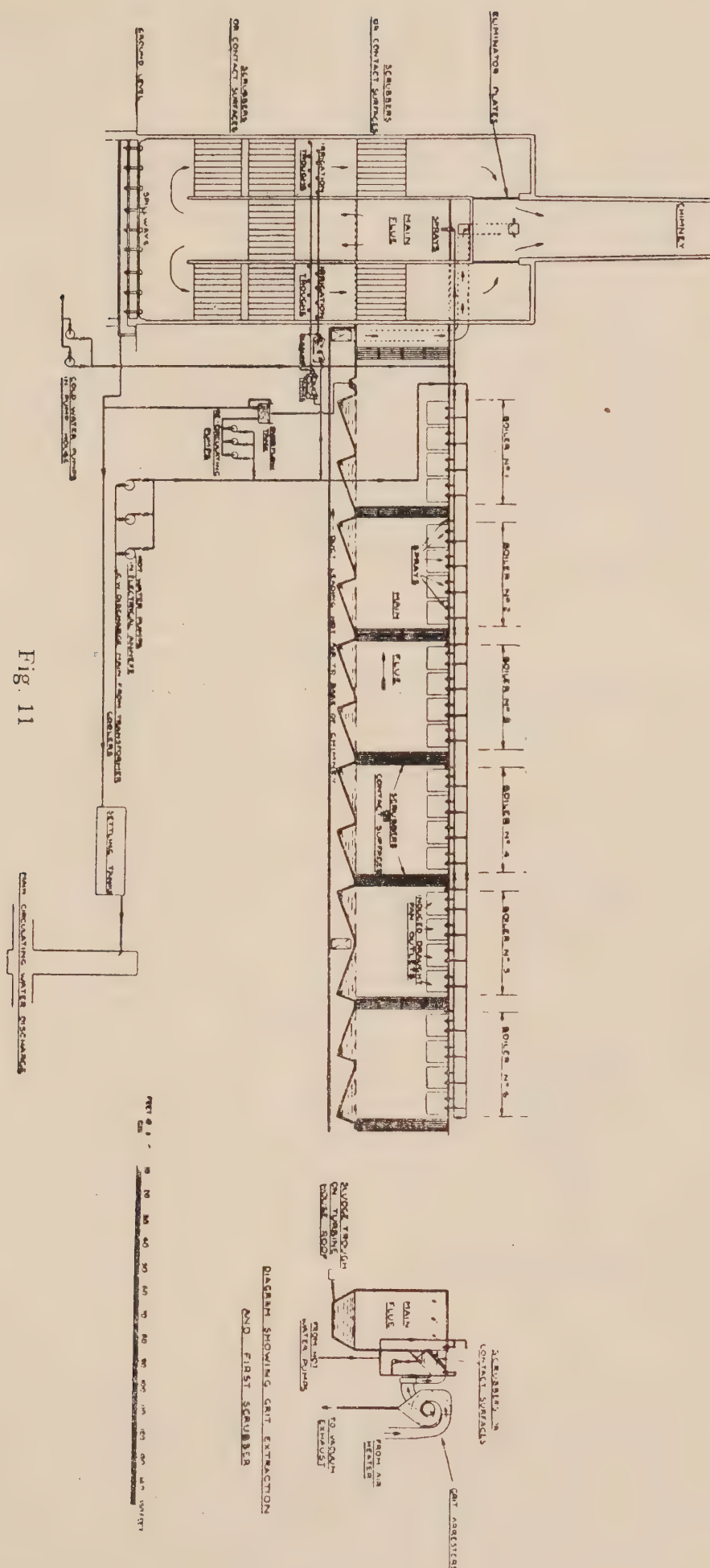
Fig. 10

installation of a wet separator inevitable, viz.: no dry separator will remove sulphur from flue gases, whereas any wet type designed to remove sulphur will incidentally also remove dust, generally at a high efficiency. Thus whenever transmission costs or other causes make it worth while to erect a large power station in a town and to face the expense of compulsory sulphur removal, dust will be removed by some form of wet washing.

As in the present paper it is not proposed to deal even briefly with the question of sulphur removal, certain types of plant will be considered merely as dust removers, but it will be understood that in so doing their principal function will be ignored.

As has already been indicated earlier the simplest form of wet washer consists of a settling chamber, with or without baffles, in which dust precipitation is assisted by means of water sprays. It is, however, extremely difficult, on account of surface tension effects and other physical phenomena, to wet finely divided dust, so that any system of water sprays is inefficient unless very large quantities of water are used, with the result that the mixture of dust and water is removed from the system as a very weak slurry. This generally involves further treatment to remove the solids from the water before disposal, a problem comparable in magnitude with that of removing the dust from the gases themselves.

Although originally used only to assist in settling dust in relatively small installations, since powdered fuel firing and sulphur removal have become more usual, spraying has been applied on a large scale. In one well-known London power station the spray system is used to deal with one-and-a-half million cubic feet of gas per minute, and the gas takes 30 secs. to travel through the plant, figures which give some idea of the dimensions of the precipitating chambers without auxiliary gear. Some 20 tons of water are passed through the sprays for each ton of coal burned, without counting the fact that the effluent is diluted with 25 times its own bulk of condensing water from the turbines to neutralise its acidity before discharge to the river.



In this application, Fig. 11, the gases leaving the boiler house first pass through a dry centrifugal separator to remove the coarse grits, and then through a series of spray chambers and iron scrubbers located partly in a huge flue and partly in great

chambers situated at the base of the chimney. Before passing up the chimney the gases are given a final wash by being passed through wooden scrubbers sprayed with an alkaline solution.

The very thin slurry containing suspended solids passes to a series of settling and filtering ponds in which the coarser particles are removed by settling, and the finer particles by upward flow through trays containing water worn pebbles and sand. These are periodically back flushed and the comparatively thick slurry removed by this operation is passed over rotary filters from which the dust is removed as a cake and finally disposed of.

The outstanding advantage of the system is the removal of sulphur and the incidental removal of dust, and the fact that, if conditions justify the expense, both operations can be carried out at high efficiency. The attendant disadvantages are primarily the high overall cost, the large space occupied both by the separating plant itself and the auxiliary plant—particularly that dealing with slurry disposal—and the enormous volumes of water which must be available and purified. Other disadvantages are the unavoidable reduction of the chimney gas temperature, with its effect upon draught, and the various effects resulting from the considerable quantities of water which are mechanically carried forward by the gases as a fine spray, appearing as a white plume at the chimney top.

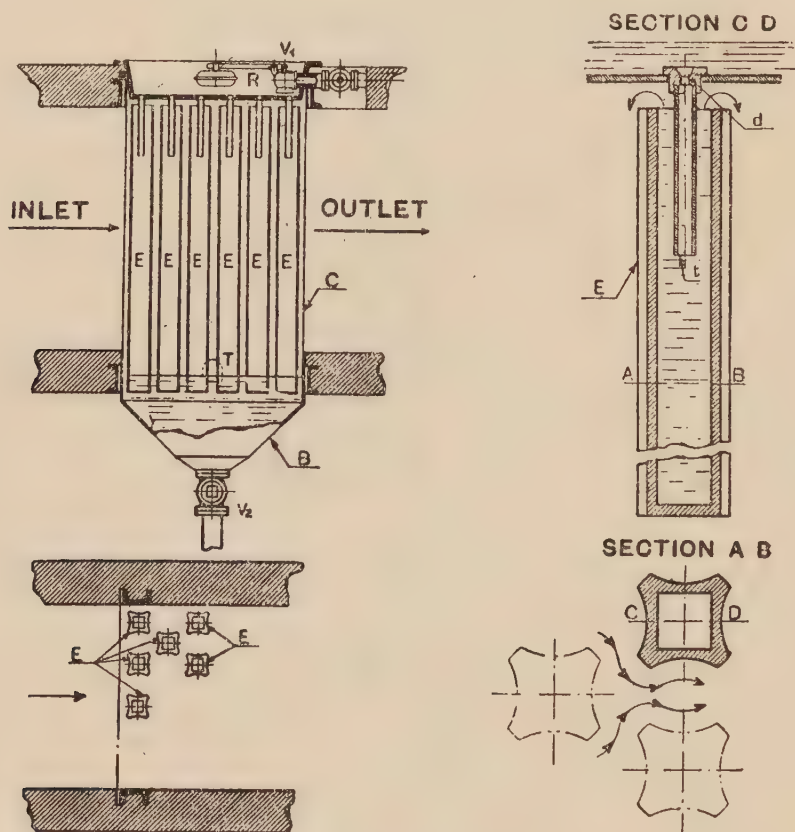


Fig. 12

In some wet washing systems sprays are either dispensed with or used in conjunction with films of water in contact with suitable metallic or wooden surfaces, in which case it is claimed that the proportion of water carried forward is considerably reduced.

In the system shown in Fig. 12 the gases pass in a horizontal direction through a series of staggered vertical tubes or elements of special cross section which are continuously wetted by a thin film of water running down them. The water is supplied by a constant head tank to a series of short pipes which deliver it to the elements which are hollow, closed at the bottom and open at the top. The water then runs down the elements into a suitable sealed tank at their base carrying with it the dust which has been caught by contact with the film. The dust laden water is run off as a weak slurry for separation in settling tanks, thickeners, filters, etc.

Certain limitations are imposed in the design of this apparatus, as in all others. Thus if the velocity of the flue gases is too high they tend to "strip" the film from the elements and this not only increases the amount of water necessary to maintain the film, but it also increases the quantity of water carried by the cleaned gas. The elements are heavy and therefore costly and they present a comparatively small surface to the gases in relation to their bulk. Too many elements also increase the pressure drop through the system if arranged close enough to be effective. Scaling and corrosion effects have also to be allowed for. In addition, there are the disadvantages associated with any wet system of high cost of slurry disposal and of the provision of fresh or purified water. Nevertheless, in spite of these disadvantages, the system is definitely of sufficient merit to be installed in numerous plants.

There are, of course, many places where the sulphur removal problem makes a wet washing system imperative, but where unlimited supplies of water are not available or else the disposal of effluent presents serious difficulties. To meet such cases a non-effluent system has been devised in which the only water leaving the system is that contained in the thick slurry or filter cake which is carried away from the site for dumping.

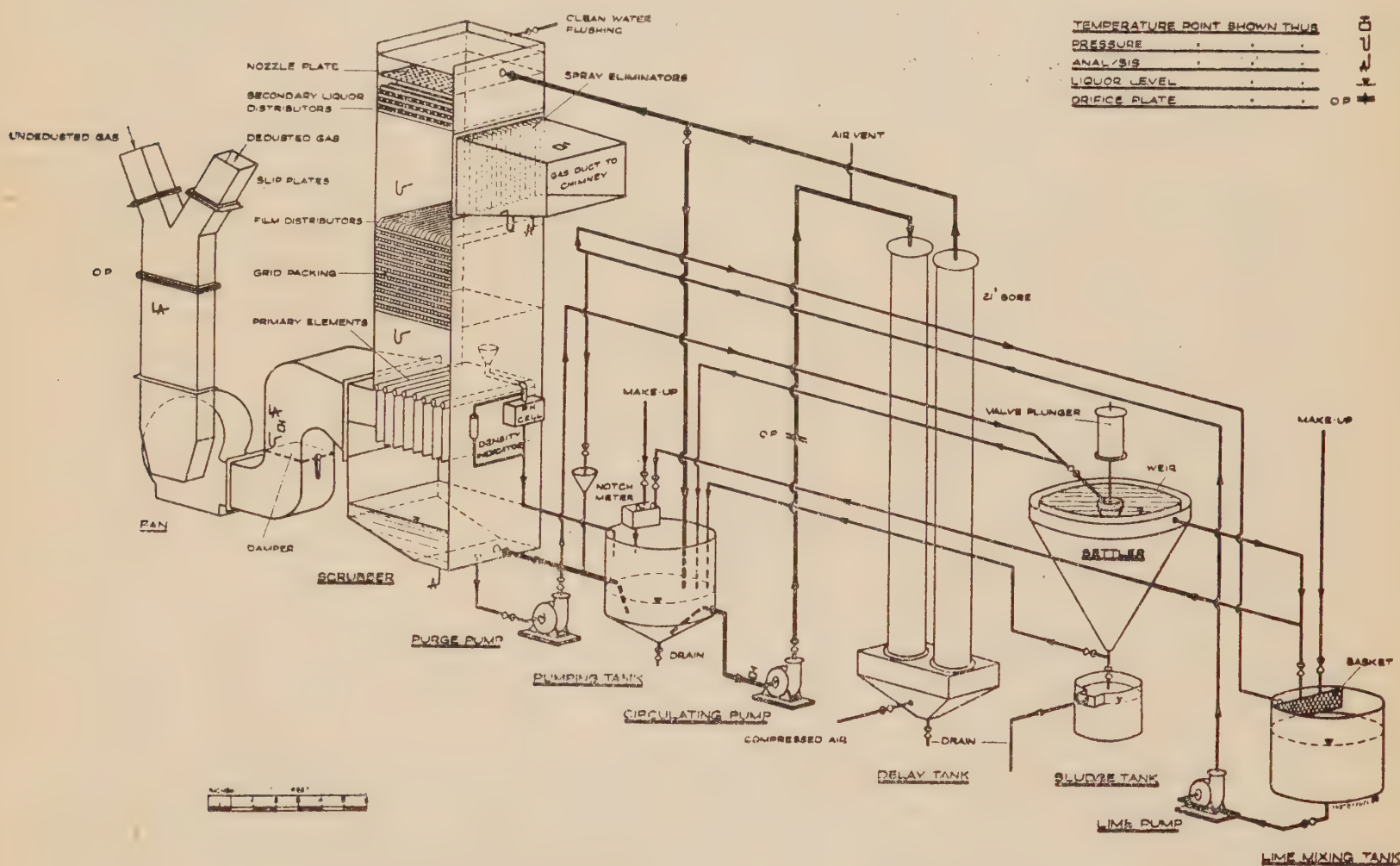


Fig. 13

In this type of plant, which is shown diagrammatically in Fig. 13, the designers have concentrated firstly upon devising a form of film scrubber which reduces the scrubbing space to a minimum without increasing pressure drops, secondly upon a method of recirculating alkaline water without causing scaling upon the scrubber surfaces and finally upon apparatus to give automatic control of the condition of the liquor in various parts of the system.

The scrubbing surfaces consist partly of special scale resisting flat wooden surfaces and mainly of a simple arrangement of spaced wooden laths. It is claimed that a 3 ft. 6 in. depth of this packing will remove all the dust above 10 microns. The

pressure drop through the packing is small, but this is to be expected as the velocity cannot be allowed to exceed 5 ft. per second without stripping the film from the scrubber.

The problem of preventing scale formation is mainly a question of the removal of calcium sulphate from the system. This is effected by supplying the scrubbers with liquor just saturated with calcium sulphate at such a rate that although it becomes super saturated at the exit of the scrubber, the extent of the super saturation is such that the crystals are retained in solution during the time the liquor is in contact with the scrubbing surfaces. Before recirculation the super saturation is removed by settling out the crystals in a suitably proportioned "delay tank."

It will be realized that to control the saturation of the circulating liquor within the narrow limits required necessitates extremely careful control, and for this reason it has been necessary to design the special control instruments, in particular pH recorders, referred to above.

The system has not yet been tried sufficiently widely in commercial operation for its possibilities to be fully known. Its advantages are, of course, the possibility of obtaining high efficiency in the removal of sulphur and dust, including fine dust, and the fact that large water supplies are not required. It has, however, also many of the disadvantages of other wet systems, including complication, the slurry problem and in particular high capital and running costs.

Testing of Dust Collectors.

From the foregoing it will be realized that the efficiency of a dust collector will depend very considerably on the size of the dust particles that it has to handle, and that no comparison of collectors is possible without a knowledge of the size of dust collected. Thus a very simple type of collector used for gases containing only coarse grits may show a high efficiency, whereas a highly specialized design in connection with pulverized fuel may show a relatively low efficiency. Similarly the degree of concentration of the dust in the gases will affect the efficiency of a plant when the dust content of the gases varies.

The following figures taken from the published data of firms manufacturing dust collecting plant are given as illustrative of claims that are made, but for reasons which follow such efficiencies must in some cases be considered as pious hopes rather than scientific facts.

Type of Plant	Efficiency %
Cyclone	50 — 75
Cyclone and sprays	92
Electrostatic	75 — 95
Wet (film)	90 — 95
Wet (spray)	94
Packed towers	98 — 99

The efficiency of any form of dust collecting plant is extremely difficult to determine absolutely, since to do so requires the measurement of the total solids contained in the gases both before and after the plant. This involves in the first place the taking of a proportionate sample of the gases which shall be an accurate representation of the whole, both as regards the total solid content and the grading of the particles. For accurate sampling the gases should be drawn from the flue at the same velocity as they flow past the sampling point and in a parallel stream. The taking of such a sample in a flue of ordinary dimensions where gas velocities, concentration of particles, etc., may vary considerably from point to point is a problem of the greatest magnitude and it is easy to understand why alternative methods of estimating the dust content of gases have been sought after.

The apparatus used for collecting the sample must also be 100% efficient in retaining the whole of the dust in such condition that the quantity may be measured. If filters are used they must be so proportioned as to collect a sufficient amount of the dust for

accurate determination without having to pass an excessively large gas sample, and to avoid variation in the gas sampling rate due to the building up of the dust cake on the filter surface. Where a plant is guaranteed to arrest all dust above a certain minimum size it will, in addition to measuring the quantity of dust, be necessary to examine the sample to determine the grading of the dust particles. In such cases the usual sieving methods are not practicable owing to the small minimum size of particles, and while elutriation methods are theoretically most comparable to the actual principles of dust settlement, they have not yet reached the point at which an apparatus can be standardised.

The determination of the efficiency of a dust collector in absolute terms is essential from the point of view of the manufacturer and the user, who wish to know that the plant will in fact do what it has been designed to do.

For the normal daily control of the plant and to satisfy the requirements of local smoke inspectors, a simpler and more arbitrary means of estimating the dust concentration is required. The actual emission from the stack can be compared with other standards, such as by visually comparing the cloud leaving the stack with shaded cards or transparencies of varying gradation. These methods are represented by the Ringlemann charts and other screens, but deductions from such observations must only be considered as approximate since the methods are open to a number of very serious objections, such as the effects of the size of the particles, the colour and thickness of cloud column, the distance of the chimney from the observer, and of the background and the incidence of light upon the smoke. Different observers will disagree in their estimation of the density of any given stack cloud.

Many of the above objections may be eliminated if the dust laden gases are viewed through a hole cut in a flue, where the depth of the gas stream is constant and a constant source of artificial transmitted light can be used for illumination. The most suitable position for such observations is in the chimney, since this is usually the only portion of the flue system where the gas stream is of reasonably stream-line flow. To obviate the human error in observation a photo-electric apparatus can be used for recording the density of the dust cloud, but for the record to be of actual value the optical density must be correlated with other factors, such as boiler load, composition of flue gases, size, shape and composition of the dust particles.

A committee of the British Standards Institution is engaged on the preparation of a standard method of testing dust extraction plant, and is carrying out experimental work to discover a method by which a reliable sample of flue gases can be obtained, to determine the best means of securing uniform flow of the gases in a chimney for measurement and sampling, and to decide on a method of determining the size of dust particles by means of elutriation. The work is extremely laborious and necessitates the taking and examining of large numbers of dust samples and investigation of numerous dust collecting devices, filters, etc. To carry this work to a satisfactory conclusion further experimental work must be done on actual boiler plants, involving the cutting of the chimney for installing the necessary apparatus, and it is essential that the plant conditions should cover as wide a field as possible in order that the influence of all the variable factors should be accurately assessed. The co-operation of industrial concerns is needed for this but up to the present most owners of boiler plant seem chary of allowing investigations to be carried out on their chimneys, and the work is severely handicapped in consequence.

Since this work is of national importance it should be possible to ensure that in the future at least no important boiler installations should be completed without provision being made for fitting such apparatus as may be agreed so that determinations of dust in the flue gases may be made at any time, as well as to ensure accurate control of the dust preventing appliances. There is unfortunately ample evidence everywhere of the need for directing still greater attention to methods of preventing emission of dust and grits from industrial plants, first by improvement in furnace design and operation, and secondly by installing suitable efficient dust arrestors.

Table 1.

Annual Consumption of Coal in Great Britain in Various Industries.

	Thousands of Tons.									
Domestic purposes	40,000
Public Utility services	12,200
Railway locomotives...	12,300
Gas undertakings	18,000
Coke ovens	18,360
Collieries	11,600
Mines and quarries	15,534
Iron and steel	9,056
Engineering and shipbuilding	1,298
Non-ferrous metals	623
Vehicles	456
Textiles	6,952
Leather	228
Food, drink, etc.	3,424
Chemicals	3,808
Paper and printing	2,555
Timber	127
Cement	1,733
Bricks, pottery and glass	5,142
Rubber	394
Linoleum	253
Other industries	483
										164,526

DISCUSSION.

Mr. George W. Farquharson (Senior Smoke Inspector, Birmingham) speaking in relation to the determination of the efficiency of dust and grit collectors in absolute terms, said he thought it was a very important point. For example, within recent months his committee had recourse to start proceedings against a very large combine for the emission of grit from the chimney stack serving one large water tube boiler. Chain grate stoker, burning fines and fitted with Dry Cyclones and Balanced Draught. After a lengthy argument it transpired that the grit arresting apparatus was guaranteed to arrest 90%—95% of the catchable grit, apparently it was the uncatchable grit which he had shown as evidence. Could the authors give him a definition as to the term "catchable grit"?

From a Smoke Inspector's point of view it was his opinion that the use of the Rengleman's Chart was useless for the observation of grit and dust emission. It had been his experience to have found cases of grit emissions and dust deposit when the offending stacks had shown a brown smoke haze. When one took a grit case to Court, one wanted evidence that the grit was being deposited so as to cause a nuisance, and no shade on a Rengleman's Chart gives that evidence. Did the authors agree to this?

The emission of grit and dust from indus-

trial chimneys, including Power Stations, was on the increase, mainly due to economic reasons and the desire for higher efficiency, and it was his opinion that the time had now arrived when the Ministry of Health should give the Local Authorities a lead as to the size, density, volume and nature of grit and dust emissions which constituted a nuisance under the Public Health Acts, irrespective of the best practicable means clause.

Mr. V. R. Chadwick (Turbine Furnace Co. Ltd.) congratulated the authors on the excellent paper just presented, but was of the opinion that more consideration should be given to the financial side of the problem. Many of the big power stations erected in this country which had adopted apparatus for the arrest of dust and grit emission had had to spend as much money on repairs and maintenance as the original cost of installing the apparatus. Thus, the initial expenditure was not the only one which had to be taken into consideration when installing apparatus.

In addition to its high cost, it had been found that such apparatus was not doing all that it had been hoped it would have done.

Dr. R. Lessing said that the pollution of the air with solids, as measured by the deposit gauges, had not decreased in quantity during the last twenty years. This seemed odd in

view of the great advance in the use of smokeless heating agents and appliances. The explanation was that the pollution had changed in character. Much of the tarry soot was being replaced by grit and dust, consisting of ash and coke particles from industrial furnaces and from installations standing mid-way between these and the domestic fire. He had discussed the conditions for the production of the various types of emission of solids in his paper on "The Sources of Atmospheric Pollution" submitted to last year's Conference in Bristol, and he had dealt with the underlying scientific principles in his introductory address to the technical section of the general discussion on "Disperse Systems in Gases" held by the Faraday Society at Leeds in April, 1936. Messrs. Barber and Hurley had given a very useful summary of the methods available for dealing with industrial grit and dust emission. To make these methods really effective, it was necessary to establish the conditions with which they had to deal, i.e., incidence, rate of formation, concentration in flue gases, velocity and chemical and physical properties of the solids that were to be eliminated from the gases before emission from the chimney. This was the direction in which the survey he recommended at Bristol would be found useful.

It should also be remembered that the material extracted by the various contrivances differed in some respects from the portion that escaped extraction, and allowing for those differences it was possible to correlate deposits collected in the vicinity of factories or power stations with the contents of the flue gases emitted by their chimneys and even with the corresponding components of the coals burned.

He trusted the authors would not mind his making a slight correction in their description of the sulphur extraction process for which he (Dr. Lessing) was responsible. The problem of scale prevention was solved not by keeping the newly-formed calcium sulphate in solution, but by forcing it to crystallize on the surfaces of calcium sulphate crystals, purposely allowed to accumulate in the washing liquor and maintained in proportions which formerly had been considered the very source of incrustation. The time required for this crystallization to take place had been worked out by laborious investigations and the results led to the incorporation of the delay tanks in which the liquor was completely de-supersaturated and thus made innocuous before it was returned to the washer, still containing its full complement of crystals in suspension.

Mr. L. H. Dibblin (Willesden) reminded the meeting that he had repeatedly drawn attention to the menace to public health from grit emission at a number of previous conferences and he congratulated the authors on the educative and very informative matter contained in their paper.

On the question of the percentage of catchable grit from flue gases he was of

opinion that the claims of manufacturers were overstated; the authors had pointed out the extreme difficulty in obtaining a fair sample of flue gas and even with the greatest care how reluctant they were to say the average from a number of samples aspirated from different positions in the flue was a true indication of the actual dust content in the flue gas.

The speaker asked (1) other than for reasons of a slight additional cost, why was the coal not washed before use? (2) Why was a better grade coal with a lower inherent ash content not used? Either measure would give less work to do whatever grit arresting apparatus was used.

When installing an apparatus it would appear that provision was not made for the additional tax put upon it during the process of "sootblowing" which took place at least once in each eight hour shift and it was at this period most grit was emitted.

In his experience a reasonably efficient plant failed to arrest the minute particles of 20 microns or less and it was these finer particles which entered dwellings, even through closed doors and windows, to be deposited on, and so contaminate, foodstuffs. It was gratifying to learn from Dr. Lessing that they would soon be in a position to say by an analysis of a certain grit it could be traced to its source; heretofore the greatest weakness in a prosecution had been the inability to prove that a certain grit had, in fact, come from a particular chimney.

Bailie Alex. Munro (Glasgow) stated that in Glasgow nothing but washed fuel was used in the power stations. He quoted tests which had been carried out which showed that 92% to 94% of the grit emitted had been arrested. He also stated that by using washed fuel 95% of the trouble was done away with.

He thought that better quality coal should be used in the plants and power stations of this country, for only by using better coal could better steam production be obtained.

Councillor C. Ramsell (Nuneaton) said that he thought he could safely say that his Council was an offender with respect to grit emission, and he would suggest the paper would have been of a more practical value if a summary of comparative costs had been included. Probably the authors could advance good reasons why they were not included.

The Council Swimming Baths in Nuneaton adjoined the Destructor Plant and on several occasions it had not been possible to use them this season owing to the excessive dust and grit emission from the above plant. It was with great trepidation that he would convey suggestions and remedies without being able to assist the Borough Engineer with comparative costs.

He gave his experience of the high dirt and ash content in some coals from data and analysis compiled on the Coal Exchange at Dagenham and implied that there was food

for thought and research on behalf of the Society. He suggested more effective screening and washing of coals would eliminate excessive grit emission and concluded by saying that he agreed with the grit arrester system given in the paper and that some form of control was necessary.

Mr. Thomas M. Ashford (Chief Smoke Inspector, Glasgow) thought the paper most opportune and very interesting in view of the increasing attention being directed to the question of grit emission generally and the necessity for effective control. So far as steam boiler practice was concerned, an increase in the emission of dust and grit must be looked for owing to the extension in the application of mechanical stokers working in conjunction with small grade fuels and forced draught.

The authors of the paper had dealt very extensively with the problem as affecting large installations such as power stations, etc., but thought that the dust, etc., emitted from the smaller installations was the cause of a more immediate nuisance because in the case of power stations these were isolated units usually attended with high chimneys, in which case there was considerable dispersal of the grit emitted over a wide area and the concentrated effects were not experienced to the same extent by those in its immediate vicinity. The number of small installations, on the other hand, was very considerable, the chimneys were invariably shorter, and as a result they were the cause of greater local nuisance. In many instances the plants were too small to justify the installation of the more expensive mechanical or electric separator systems and in such cases the spray chamber and baffle type were quite effective for removing the larger dust and grit. So far as costs were concerned he instanced a small forty-five thousand kilowatt station in the Glasgow area which had recently been equipped with Vortex type mechanical grit arrestors, these units being installed at a cost of approximately £4,500. In the spray chamber type the cost of installation for a typical two or three boiler Lancashire battery would be from £400 to £600. This had been the cost in several instances in his own area.

Owing to the increasing frequency of complaints, Glasgow had had its smoke statute extended, by a provisional order which had recently been confirmed, to include the emission of grit, gritty particles, sparks and ashes, and they considered that this added statutory power would have a definite effect on the control of nuisances of this type and be a lever to induce plant users and owners to adopt remedial measures where necessary.

Mr. C. D. Taite, speaking as the Chairman of the Committee appointed by the Electricity Commissioners to report on measures for the prevention of grit emission from the chimneys of electric power stations, said that that Committee, after a thorough investigation of the problem, had submitted a full report to the

Electricity Commissioners on the subject and that report had been acted on by the Commissioners. This body, when issuing authority for the construction of a new generating station or an extension of an existing station, now required the owners to submit proposals for the approval of the Commissioners for the prevention of grit emission and they were arranging that new power station chimneys should be provided with observation holes so that tests could be made to ascertain whether grit emission was, in fact, being prevented.

The emission of grit from stoker-fired installations could be prevented with a proper design of flues and a suitable velocity of the gases without the necessity of apparatus. The chimney stack should also be built high enough so as to ensure the gases being carried away without running any risk of causing a nuisance either to vegetation or to buildings.

Where powdered fuel installations were installed, the most suitable way of preventing the emission of grit was the use of electrostatic installations.

The trouble now was not with the power stations, where, as already pointed out, efficient means for extracting grit were provided, but with the industrial user. He must be told how to prevent the emission of smoke and grit and he must be told authoritatively. The Government should appoint a Committee to make a thorough investigation of the problem, so that the industrial user could be told what steps he must take to deal with the smoke and grit problem.

Messrs. Barber and Hurley, in reply to the discussion, stated that it was not possible to define in measurable terms what had been spoken of as "catchable" grit. As was shown in the paper, the smallest size of grit caught by a given apparatus depended upon its type and its size. A figure frequently mentioned was, however, 20 micron in the case of centrifugal apparatus. The present tendency in specifications for modern appliances was to demand a maximum total discharge under specified conditions with a second limit for the material greater than 20 μ .

With regard to the use of Ringelmann Charts it was theoretically not possible to correlate the appearance of a smoke with its dust content, but, in default of a better method of estimating a nuisance, appearance was frequently used for practical purposes. A further difficulty was that appearance itself was affected by atmospheric conditions and by the position of the observer. Tests at the Fuel Research Station with a number of different methods of observing the appearance of fixed smokes had shown the simple Ringelmann Chart to be surprisingly consistent when compared with and more elaborate methods.

Referring to the cost of dust separation, no figures had been given in the paper on account of the wide variations which occurred not only with different types of apparatus but also with the size of the installation, the type of dust and

the efficiency specified. Some figures had been given in the discussion by Mr. Ashford, others would be found in the report of the Electricity Commissioners.

The authors agreed that the use of cleaned coal would help to reduce atmospheric pollution. As almost any type of coal could now be burned efficiently under boilers the selection of the coal to be used was entirely a matter of economics and users bought the coal which they thought would have the least overall cost. Fortunately it was more and more being realized that coal should be bought in terms of heating value rather than by weight and as a result the use of cleaned coal was rapidly increasing.

It could not be denied that although most attention was paid to the grit emitted from power station chimneys the smaller users in the aggregate were responsible for most pollution, but on the other hand the power stations emitted the largest quantities of dust at a single point and, although their cleaning costs were high, their burden was less than that which would have to be borne by a small user if he were required to conform to the same standards. It was, however, most desirable that some inexpensive and efficient form of dust remover suitable for small undertakings should be evolved and its use insisted upon.

Second Session, Wednesday, 14th October, 1936, 2-30 p.m.**Introductory Remarks by the Chairman, Dr. R. Lessing.**

The development of the pioneer work of the National Smoke Abatement Society has reached at long last a stage of transition from a movement initiated by enthusiasts, expressing pious hopes, to the recognition that the evil must be attacked by modern methods of scientific investigation and by preventive or remedial treatment with the powerful aid of up-to-date technical resources. There is ample proof of an urgent demand by the general public and the hitherto intransigent section of industrialists, as exemplified by the outcry raised against the erection of large Power Stations in the heart of the metropolis and the ready response of the industry and its advisers in providing effective means for the entire elimination of flue dust and sulphur from the vast volume of chimney gases released in the boiler installations at Battersea and Fulham. The call for prevention or abatement of atmospheric pollution is no longer the self-imposed task of those who in the past had to suffer themselves to be regarded as cranks in the pursuit of an æsthetic ideal, but it has become a major problem of practical politics in our economic, technical and sociological development.

In a paper submitted to last year's Conference at Bristol, I had the privilege of indicating the fundamental causes of atmospheric pollution and I then suggested a general survey of the individual factors contributing to it. In April of this year the Faraday Society devoted three days at Leeds to a most fruitful General Discussion of the scientific and practical aspects of disperse systems in gases which constitute smoke, dust and fog, and notable contributions were made by British and Foreign Authorities.

The growing interest in these matters is producing results which permits us to stop generalizing and to establish the individual factors bearing on the complex problem of the contamination of the air, steps which are bound to lead to practical improvement. The papers before us to-day prove conclusively a trend in this direction. The iron and steel industry and the clay industry with an annual coal consumption of 9 million and 5 million tons respectively, or a total of about 9 per cent. of this country's total consumption, are examples of industrial groups which in the past have been and to an appreciable extent still are, responsible for a serious contribution to the production of smoke and sulphur acids. The authors show the great advances that have been made, the difficulties that had to be faced and the problems still remaining to be solved. If it is remembered that 60 per cent. of the gas supplied by the Sheffield Gas Company, comprising its own manufacture and that of the coke ovens connected to the South Yorkshire Gas grid, is used by the local steel makers, mainly in substitution of raw coal, it will be recognised that this trade is contributing considerably to smoke abatement and and presumably finds it profitable to do so.

Those who have at heart the purity of the air we breathe, quantitatively by far the largest item in our daily diet, may look with hope and confidence into the future, but it is one of the paradoxes of the development of civilization that the turning-point in the history of air cleaning happens to coincide with a feverish activity of the nations of the world in evolving methods and materials by which the atmosphere can be polluted with substances more poisonous and obnoxious than any with which the grossest neglect or ignorance of fuel consumers in the past has contrived to contaminate it.

MODERN METHODS OF DEALING WITH SMOKE PREVENTION PROBLEMS IN THE IRON AND STEEL INDUSTRY.

By H. C. ARMSTRONG, M.Inst. C.E., F.Inst.F.

The prevention of excessive smoke in the Iron and Steel Trades probably offers greater problems than in any other industry on account of the great diversity and peculiarity of the conditions of heating that have to be observed in the various processes employed. Since the passing of the Public Health (Smoke Abatement) Act, 1926, the manufacturers have paid increasing attention to the matter in an attempt to improve conditions, and the author would like to express his indebtedness to the Conference for this opportunity of putting forward the case on behalf of the Steel Industries. The very fact that a paper on such a subject should be asked for by those nationally interested in Smoke Abatement is a welcome sign of the absence of any bigoted feeling on the part of the authorities who are very rightly charged with the task of obtaining a cleaner atmosphere for our manufacturing towns and cities. At one time, what are termed the heavy trades were somewhat maligned by those who did not understand the difficulties with which the steel manufacturer is faced. It must be confessed at the same time, however, that there was considerable justification for many of the complaints levied at the steel works and much praise is due to those bodies, such as the National Smoke Abatement Society who have certainly had an uphill task in their fight against black smoke.

What is now being done in the Sheffield district may be taken as fairly typical of the steel industry as a whole. Anyone interested and paying a return visit to Sheffield or Rotherham after an absence of some twenty years cannot fail to be struck with the marked improvement. Formerly black smoke and even flames were to be seen in every direction issuing from chimney stacks. Such a sight to-day would call down the wrath of the management before the Smoke Inspector could reach the works to make his complaint. This does not, however, mean that perfection has been obtained. This is still a long way off, but the whole subject is now being tackled from a scientific as well as practical point of view. Black smoke is waste and it is naturally the first object of the manufacturer to avoid such loss, although he is usually equally anxious to attend to the aesthetic side.

Scientific Research.

It may be a matter for argument as to how far the improvement would have proceeded had not the local health officials, backed up by legislature, forced the pace, but realization of the problems of reasonable elimination is well to the front in the minds of the engineers concerned. The joint action of the Sheffield and Rotherham manufacturers may be cited as illustrative of what is now being done. Although for several years there had been a Committee of Manufacturers specially convened to examine the question of smoke abatement research, it was not until 1928 that the Committee joined hands with the Corporation to work together to examine the whole question under the chairmanship of one of the professors of the Sheffield University. A review of the whole position was quickly found to be necessary. The National Federation of Iron and Steel Manufacturers wholeheartedly co-operated and appointed two independent investigators from the staff of their fuel research department. After these had made a report, a whole time investigator was appointed to work at the University under the supervision of the Professor of Fuel, the necessary funds being provided by all the parties concerned.

The most important result, other than the valuable reports issued by the University from time to time, was the general interest aroused amongst manufacturers, including those who might have been somewhat sceptical at the outset. As might be expected, although the solutions of many of the problems were forthcoming, financial considerations played such a prominent part that only a few of the remedies could be put into

immediate operation. The slump in trade and impossibility of embarking upon large capital expenditure slowed up progress for a while, but with returning prosperity the need of new furnaces arose and it had been possible in many instances to instal heating plant without the old faults of heavy smoke emission. It has been estimated that the cost of rebuilding a furnace on the most modern lines to replace one fired with raw coal is at least 30 shillings per ton of coal burnt by the furnace in one year. As this may amount to thousands of tons this alone must make conversion a gradual process. There are in use also a very large number of furnaces which offer technical, as well as financial, difficulties to the elimination of black smoke production. These are being worked under conditions which are unavoidably highly conducive to smoke and it is upon those that the Fuel Technologist is now concentrating.

Smoke composition and formation.

It must be realized in any discussion of smoke prevention that it is almost impossible to burn smoke once it has been formed. The ideas and inventions put forward from time to time with a view to burning smoke, the apparatus designed to consume any smoke produced in a furnace are all unscientific and bound to fail. Smoke is the result of incomplete combustion. In order that the combustion of any fuel may be complete, three main rules must be observed. There must be sufficient oxygen; there must be intimate mixture between the oxygen, or air, and the fuel; and the temperature must be sufficiently high to continue the burning. The well-known experiment with an old-fashioned paraffin lamp is a good illustration of the need of the observance of these rules. Leave the chimney off and the flame from the wick flares up causing smoke. Replace the chimney and the amount of air is controlled, the flame is no longer cooled, and the smoke disappears owing to proper combustion. Smoke is formed from the distillation products of coal. These are tarry vapours and hydrocarbon gases which vary in their composition according to the temperature at which the distillation is carried through. The hydrocarbons are the chief factors in smoke formation since, not only are they comparatively difficult to burn, but, as pointed out by Bone, form soot, or free carbon, when the combustion is incomplete as is consequent with insufficient air. Once this soot or black smoke appears it cannot be made to burn however much it is brought in contact with highly-heated air. The lower the temperature at which the volatile gases are released from the coal the more difficult it is to make them burn.

Unfortunately it is extremely difficult in furnace practice to observe the rules of combustion and at the same time satisfy the heating conditions required by the material. Consideration of the happenings in a boiler furnace will show that here the conditions are much more favourable to the prevention of smoke. Raw coal is added to the white hot fire which mainly consists of incandescent carbon. The volatiles are at once released. If the fire is in the proper condition the temperature is high enough to avoid the production of low temperature hydrocarbons. If the firebed is of the correct depth and evenness sufficient air is passing through to mix with the rising gases and 'burn' completely the high temperature hydrocarbons. As is well known, complete combustion can only be obtained when from 20 to 50 per cent. excess air is passing through the boiler fire. This excess air does no harm as it passes away through the boiler to the atmosphere. This is not the case where steel is being heated. In practically every furnace operation excess air is absolutely precluded on account of its injurious effect on the material. For the same reason a thin fire would be prohibitive and firebeds of from one to two feet in thickness must be used.

In a boiler it is possible, owing to the rate at which the heat is absorbed and carried away by the boiler water, to maintain the temperature of the fire considerably above the danger point at which smoke is liable to be formed. The hotter the fire the greater the *quantity* of heat that is transmitted to the water which itself never gets any hotter than the temperature corresponding to the pressure of the steam at which the boiler is worked. In the steel worker's furnace the temperature of the burning fuel must bear a close relationship to that at which he wishes to work the metal. He must work his

fire to the job and cannot consider smoke prevention alone. Smoke not only does no harm to the steel but is evidence that the atmosphere of the furnace contains no excess air which would cause injury through oxidation or scaling. Nevertheless, so readily does steel oxidize it is impossible to avoid scaling however much attention is paid to the fire. The amount permissible depends upon the class of steel being heated and the amount of machining that has to be done afterwards. In the case of the special steels for which Sheffield, for instance, is famous, scaling must be reduced to an absolute minimum.

The two main factors of all furnace control are the obtaining and maintaining of the correct atmosphere and temperature. That the safest, if crudest, way of ensuring that the atmosphere is harmless should be indicated to the furnace man by the presence of smoke is unfortunate, but explains the statement made some years ago by a prominent metallurgist that Sheffield steels could not be made without smoke. Although in the light of present knowledge this would require considerable modification, the necessity for the correct atmosphere is equally, if not more than ever, vital. Scientific research is being vigorously carried out on this important matter about which there is still much to be learnt.

Furnace problems.

It will thus be seen that the steel manufacturer is fully alive to the possibilities of obtaining the required safe conditions by other means than the old method of heating in volumes of black smoke. As a general rule, the new furnaces now being built are a great improvement on the original designs and will considerably reduce the amount of smoke made. Nevertheless, so many furnaces depend upon raw coal for their fuel that smoke must be unavoidable to a certain extent. There are still an enormous number of furnaces consuming thousands of tons of coal each week which cannot be converted to other fuels without a great deal of money being spent. It is obvious it is impossible to abolish every furnace that is fired with coal, nor is it necessary.

Reorganization of plant is usually planned a considerable time ahead, years sometimes elapsing before it is possible to carry out alterations which have been thought out previously. Examples could be found in every works where it is known that sooner or later it will be necessary to re-arrange certain plant and to erect the furnaces elsewhere. In such circumstances the immediate replacement of the existing 'crude' furnaces by those of a more advanced, if expensive, design could not be justified. No manager would care to build a new furnace to prevent smoke if it is to be pulled down again long before the furnace could pay for itself.

There are furnaces which give satisfaction from day to day when heating the general run, but which are occasionally called upon to treat abnormal steels. Under the latter conditions smoke emission may be excessive, but it is not practicable to build a special furnace which might be standing idle for long periods.

Heat treatment is the most difficult of all processes to be conducted smokelessly. This process consists of heating metals at various temperatures from about 500°C. up to 1000°C. and occasionally over. The requirements of a heat treatment furnace are :— definite and uniform temperature, ease and speed of heating, suitable and controllable atmosphere. These factors are all opposed to the requirements of good combustion. The comparatively low temperature is entirely contrary to the law of combustion that demands high temperature. The danger of oxidation or surface attack is greater since heat treatment is usually given to the finished job which permits of little or no after machining to remove any defects from scale. It will nearly always be found that complaints from Inspectors of excessive smoke refer to furnaces in which low temperature treatment is being carried out.

Another hindrance to smokelessness, or at any rate to its diminution from heating furnaces, is the growing tendency for slow heating and complete thermal control throughout the manufacture of many important pieces of machinery. When heating

has to be conducted with the gradual rise of only a few degrees per hour it is very difficult to quicken the fires to give better combustion.

Amongst the problems before the furnace manager who wishes to cut down smoke the most difficult is that of the cold furnace. Smoke is unavoidable until the furnace is hot enough to prevent the production of smoke through incomplete combustion in the fire box. Where the furnaces supply continuous production mills or hammers this need only cause serious smoke at the commencement of the week with slight emissions when the fires are cleaned and rebuilt, but, unfortunately for the cleaner sky advocates, many steels must be heated up slowly from cold and would be injured beyond repair if suddenly placed in a hot furnace. This happens several times each week and aggravates the smoke production due to starting up. In extreme cases the rate of heating is so slow that as much as 48 hours may elapse before the furnace is hot enough to prevent smoke.

The author has no wish to stress unduly the difficulties with which the steel manufacturer has to cope, but the laws of combustion are irrevocable. If black smoke is to be prevented, other means must be devised which will overcome the reluctance of the heavy hydrocarbons to burn under the conditions of furnace heating. A very great deal is being done, even with the coal fired furnace. Smoke is waste, and the methods of fuel control now generally adopted are calling attention to this aspect of combustion and automatically improving the firing side. More careful firing, adoption, to a reasonable extent, of the maxim of little and often, small improvements in design when rebuilding and more general supervision by the management have all done a great deal. It will be a long time before raw coal is abolished as a fuel. It is the cheapest, the most readily obtainable, is burnt in furnaces of the simplest and cheapest design, and will continue to be the favourite fuel in the future. It is very elastic. The man with the shovel has become an artist at his trade and has a very wide range of rates of firing at his command. Pyrometry has shown that the results of careful firing are equal in many instances to those from what might be thought to be better fuels or furnaces.

Fuels employed in the Steel Industry.

The manufacturer has to consider costs as next in importance to results, and however great the moral demands for smokelessness must first watch his fuel bill. Heat is usually expressed by the fuel engineer in Therms—a convenient unit equivalent to 100,000 British Thermal Units. Enquiry into costs of the heat units in various fuels shows that, allowing for carriage, ash removal, works charges, etc.

Coal costs 75 pence per therm.

Producer gas costs from 1.3d. to 1.5d. per therm.

Town gas costs 2.2d. and upwards per therm.

The latter two offer advantages in some heating processes which render their higher cost less important and are largely used in the iron and steel industries.

Producer gas is a gaseous fuel which is produced by total gasification of coal in a specially arranged appliance. In its manufacture the necessary heat is produced by burning some of the coal inside the retort or producer body as against the manufacture of Town or Coke Oven Gas where the gas is formed by means of heat externally applied. Large volumes of coke remain in the latter case. Producer gas, in consequence, contains a considerable proportion of nitrogen, which is useless as a fuel and serves as a diluent of the heating power of the gas. The calorific value of producer gas is usually of the order of 160 B.Th.U's per cubic foot. This is low and necessitates pipes or flues of several feet in diameter owing to the large volumes which have to be carried. The tarry matter which is distilled from the coal when it is first fed into the producer is carried along with the gas, but leaves it as the temperature of the latter falls. Were it not for this tar mist producer gas would be more used. Its presence precludes its use anywhere except on comparatively large furnaces where brick ports are used in place of metallic burners which would soon become choked. The low heat value of the gas must be compensated for by preheating the air required for combustion.

Economically this saves fuel but increases the cost of the furnace, as large chambers are necessary in which heat can be extracted from the waste gases and returned to the furnace in the air that is required. It is practicable to use producer gas for nearly all temperatures and heating operations if the furnaces are fairly large. Combustion conditions will produce a satisfactory furnace atmosphere without the emission of smoke.

The chief objection to the use of producer gas from the view of the Health Authorities is the methods employed for cleaning the flues or pipes of the tar which accumulates therein. The usual practice is to set fire to it at the end of the week. This removes the tar and satisfies the furnace users, but unfortunately causes a fairly large amount of dense black smoke for several minutes. There is no other known method of removing the tar from the flues. Even this difficulty is being tackled by the engineers of steel and other industries where the use of producer gas is common. There are already in operation a few plants where the tar is being first removed from the gas, either by water washing or electrical discharge or by a combination of both. Proved to be practically possible this is being extended, but the cost of the clean gas is naturally greater and has to be considered. There are at present certain difficulties in the disposal of the tar and the whole process could with advantage receive the attention of the Fuel Research Authorities.

Many furnaces have been and are still being built in which a small self contained producer unit is incorporated. The connection between producer and furnace is small, and no trouble is experienced with tar. The producer grates have to be cleaned periodically causing a certain amount of interruption and fall in the temperature of the furnace. This type of firing is therefore not satisfactory when the heating requires to be continuous. The main objection to the large extension of this method of heating is the large amount of ground space occupied by the whole furnace.

Reference may be made here to mechanical stoking. The success of the mechanical grate as a smoke eliminator in boilers may incite wonder in the minds of the uninitiated that such means of firing have not been applied to reheating furnaces. Experimental furnaces have been built and their use is being extended, but very slowly. The main difficulty is in designing a grate on which a thick fire can be carried. The necessity of preventing the passage of excess air through the firebed has been explained. The boiler obtains much of its heat by radiation from the glowing fire on the grate below it. The forging furnace cannot be built in the same way and the grate being placed at one end must be of reasonable dimensions. Like many other suggestions for avoiding smoke practical difficulties have arisen which were not anticipated, but research is continuing from which some form of mechanical stoking will sooner or later emerge.

Although the ideal fuel has not yet been produced, Town Gas offers such advantages from many points of view it is regrettable that its cost narrows its use to those sections of the Steel trade in which the value of the material produced is so great as to overshadow the cost of the fuel used. Owing to the method of manufacture, only about 12,000 cubic feet of gas are obtained from a ton of coal although the gas is of a high calorific or heating value. About $3\frac{1}{2}$ times as much heat is obtained from a similar weight of coal in the form of producer gas. In the few places where coke oven gas, which is of almost similar composition, is available such as Glasgow, Newcastle-upon-Tyne and Sheffield the lower cost of the Town supply is enabling manufacturers to take very large quantities. Sheffield, like the other towns mentioned, has been quick to take advantage of this fuel and the total amount now used for industrial purposes amounts to several thousand million cubic feet per annum. In the works with which the author is connected the quantity of Town (Coke Oven) gas burnt each year is replacing over 40,000 tons of coal, by no means a slight contribution to the favourable solution of the smoke question!

One of the greatest successes in the replacement of raw coal with smokeless gas in Sheffield has been in connection with the production of high grade thin steel sheets. The furnaces used in this branch of the trade have always been bad offenders in the

direction of smoke owing to their peculiar construction. Years of experience have developed a furnace in which the material is actually heated in direct contact with the fire. The latter requires careful preparation, the hydrocarbons being allowed to escape (in the form of smoke) before the pieces of steel are put in the furnace. Experiments with secondary air and changes in design have only proved partially successful with coal firing, but the change over to gas has removed all smoke. This has been rendered possible through the installation of furnaces with a complicated arrangement of recuperators and valve gear, etc., but the cost of these furnaces is very high and can only be justified where cleanliness and atmosphere control is of first importance as in the manufacture of high quality sheets such as stainless steel, and of high carbon steels when the slightest decarbonization of the surface is detrimental. Sheets of what might be called "commercial" quality could not be economically produced with furnaces of this type. Nevertheless, the new furnaces are a distinct contribution to the abolition of smoke and evidence that the steel manufacturer is prepared to do all he can whenever possible.

The sheet furnaces referred to are only one example of the uses to which Town Gas is being put. Rolling Mills, Heat Treatment and small forging furnaces are now operated with this fuel, but in every case the fuel cost is high and there are special conditions which justify the extra expense. Extension of this fuel must improve the atmosphere of the towns where it is used, but must largely depend upon the proximity of coke ovens, and the quantity available.

Although only a few furnaces are heated with electricity their use is growing and they not only make no smoke but in most cases replace furnaces in which owing to the delicacy of the materials heated smoke was hitherto necessary.

Boiler firing.

The foregoing remarks apply, of course, to the metallurgical side of the Iron and Steel Industry, but many boilers are also used. Although no one in the trade would make any claim that the boiler side should have any consideration other than that given to other industries there are conditions which are peculiar to the work done. Variation in demand is always the bugbear of boiler firers and the changes in steam consumption can and do vary considerably. Very large tools, such as hammers and presses are used in the manufacture of large forgings. These tools work intermittently since, whilst it takes many hours of heating to prepare the ingot or steel mass, the forging operation which takes the steam occupies only a comparatively short time. When the call on a boiler for steam outputs of from 50,000 to 100,000 lbs. per hour suddenly ceases it is not easy to prevent smoke emission after the few minutes allowed by the regulations. Problems of this sort are being solved by centralizing the steam supply as much as possible, using larger boilers with mechanical grates and so levelling up the peaks and valleys of the load chart. Many of the works, however, occupy large areas and individual boilers are necessarily required at times.

The waste heat boiler, largely used in the steel trade, should not be regarded as a boiler, being attached to a heating furnace, and its operation is entirely dependant on the working requirements of the furnace itself.

In conclusion, reference should be made to that somewhat controversial affair the combination chimney. Such a chimney serves both boiler and furnace. It is naturally impossible for the Smoke Inspector to judge from outside whether the smoke comes from the boiler or the furnace, and the temptation for him to blame the boiler and the owner to do the reverse is obvious. In any case the arrangement is not the best as the two may interfere with each other. If one or more of the furnaces are not working it is difficult to avoid leakage of cold air which spoils the draught if the boiler is working alone. It is then more difficult to avoid smoke. There are not a large number of combination chimneys. To overcome the difficulty improvements are being made on the lines suggested for the furnaces. Where the furnaces are converted to Town Gas chimneys are not necessary. The modern designer endeavours to provide a chimney for

each furnace, but chimneys are costly to build and those in existence on a works are used if possible. More attention to fuel economy is of assistance as it helps to differentiate between the boiler and furnaces and shows up the offender.

Future legislation.

Enough has been given in this brief description of some of the smoke problems of the Steel Manufacturer to show that he is using "the best practicable means for preventing the nuisance, having regard to the cost and to local conditions and circumstances." Public Health (Smoke Abatement) Act, 1926, Sec. 1 (3). He is in many cases forced with apparently contradictory conditions. In spite of the fact that many heating operations have to be carried out under thermal conditions which either prevent complete combustion or render the emission of smoke irreducible he is improving and experimenting.

The subject of black smoke emission and the question of legislation on the matter is bound to be contentious. There are those who consider the progress towards smokeless conditions is too slow and would invoke parliamentary aid to force the pace. No industry, on the other hand, could exist if uneconomic and unpractical processes were forced upon them by hasty legislation.

One example of the difficulty of legislating for all happenings is that of the furnace which produces smoke owing to the failure of part of the furnace or flues. This may happen when it is not possible to shut the furnace down at once for repairs. Were prosecution to follow at once smoke could only be stopped by shutting down the whole plant, be it rolling mill or hammer, etc., with consequent loss of production and failure to give deliveries to the date promised.

It would be idle to pretend that there are no laggards, but joint action is so prevalent that no individual can afford long to ignore the use of progressive methods by the majority. Taking the long view and realizing what a vast improvement has taken place in the years immediately past the author of this paper would suggest that further legislation on the matter is unnecessary at present and might even be injurious, both to the cause of smoke elimination and to a highly important industry. The change of attitude of both parties has been so gradual that it may not be fully realized. The Inspectors who act for the Health Authorities in the various grounds are more fitted than formerly to advise and are now consulted by the smaller firms who do not possess experts to deal with furnace matters. Inspectors may be seen attending local Technical Classes on fuel and furnaces and are known to be generally sympathetic to the difficulties of plant and manufacture. Complaints from Inspectors are by no means unhelpful as they direct attention and the results of any alteration is evidenced by the frequency, or otherwise, of their visits. As mentioned at the commencement the investigations of the manufacturers are carried out jointly and experiences freely exchanged.

Much has been done. There is still more to do but the problems of smokeless heating are at least being appreciated and solution sought. More than this cannot be expected.

DISCUSSION.

Mr. James Law (Chief Inspector, Sheffield, Rotherham and District Smoke Abatement Committee) said we would like to pay tribute to Mr. Armstrong for his explicit and interesting paper, but more especially to his company for the very fine pioneer work which they had done and were doing. Mr. Armstrong had mentioned the good work done by the Research Department of the University

but he appeared to be singularly modest about the Research Work and the practical application of it which had been carried out in his own works. Many thousands of pounds had been spent and many methods which were tested in the laboratory failed when they were tried out in the works.

Mr. Armstrong stated that "In practically every furnace operation excess air is absolutely

precluded on account of its injurious effect on the material." Could Mr. Armstrong tell them of any special tests carried out to ensure the preclusion of all air? Was smoke in the furnace definite evidence that the atmosphere of the furnace contained no excess air?

With regard to the difficulty experienced in controlling smoke from heat treatment furnaces on account of low temperatures and control conditions, he was entirely in agreement, but it was not correct to state that it was nearly always found that complaints from Inspectors referred to low temperature heat treatment furnaces. The majority of complaints made referred to re-heating furnaces because they outnumbered the other classes of furnaces by about five to two.

In describing boiler loads, Mr. Armstrong was of the opinion that the variations in boiler loads were greater than elsewhere. If they made inquiries throughout England it would be found that each industry required greater peak demands for steam than any other industry. That was always the "best practicable means" defence for boiler smoke. He also stated that it was impossible for the Smoke Inspector to judge from outside whether a combination chimney emitted "boiler" smoke or "process" smoke. That was agreed to a limited extent, but a 20 minutes' emission of smoke would hardly be attributed to boilers any more than sixteen half minute burst would be attributed to the firing of a process furnace. There remained at present a considerable number of combination chimneys in the Sheffield area; in fact there had been three new ones erected in the past two years. Where mechanical stoking had been installed on the boilers the average emissions had been reduced by 50% or more.

He wished to emphasise the statement made by Mr. Armstrong that it would be idle to pretend there were no laggards. It was also unfair to companies similar to those represented by Mr. Armstrong to allow the

laggards to continue indefinitely and it was for this purpose that this Society had passed a resolution at the Bristol Conference in September last. A provisional exemption was granted for five years in 1926 to enable these laggards to come into line. Was it fair to ask for further consideration in 1936? Would Mr. Armstrong give them his considered opinion with regard to these provisional exemptions being rescinded? Was he of the opinion that they would involve any hardship by causing (a) heavy capital expenditure, (b) by temporarily restricting output, or (c) by increasing unemployment?

In concluding he would like to propose a very hearty vote of thanks to Mr. Armstrong for his interesting paper and for putting before the National Smoke Abatement Society the manufacturers' point of view with regard to metallurgical process furnaces.

Mr. Armstrong, in reply to Mr. Law, stated that apart from more or less interference whilst rebuilding was going on the effect on output should not be great, but time would be required for the change over in order to minimize this. The unemployment question was another matter. Coal fired furnaces required a good deal of labour for firing and handling the coal. That would not be required if gaseous fuel was used. The first effect would therefore be to cause unemployment. The absorption of such labour could be expected to follow on much the same lines as elsewhere where labour saving machinery had been adopted. The cost of conversion would be very high as Mr. Armstrong had already pointed out in his paper and would bear very heavily on manufacturers unless spread over a considerable time. Many furnaces which unfortunately did emit black smoke are otherwise in good condition and no owner would wish to pull down these until a return for their capital cost had been received.

THE PROBLEMS OF SMOKE EMISSION IN THE CLAY INDUSTRY, WITH PARTICULAR REFERENCE TO THE HEAVY CLAY INDUSTRIES.

By E. ROWDEN, B.Sc., A.R.C.S., D.I.C., and A. T. GREEN, F.I.C.

INTRODUCTION.

The clay industry, one of the largest industries in the country, can be divided into three main branches concerned with the manufacture of (a) refractory materials, (b) building materials and (c) pottery. The refractory materials industry is concerned with the manufacture of heat resisting materials, mainly firebricks and silica bricks, such as are used in the construction of furnaces, kilns, ovens, retorts, etc. The building materials industry is concerned chiefly with the manufacture of building bricks, facing bricks, blue and brindled bricks, salt-glazed pipes and roofing tiles. The above two branches come within what is known as the heavy clay industries. The pottery or fine ceramic industry deals with the manufacture of earthenware, china ware, wall tiles, electrical porcelain and stoneware. In each of these industries, the product being manufactured has to undergo one or more firing operations, whilst the conditions of firing, such as maximum temperature, kiln atmosphere and time of firing, vary greatly according to the product being fired.

Up to about twenty or thirty years ago, coal-fired, intermittent kilns were almost solely used for the firing of these products, except for the case of a few continuous kilns, of which the Hoffman kiln used for the firing of building bricks was the main exception. Great improvement in kilns and kiln design have since been introduced, and where previously all intermittent kilns were used, many of the larger works have adopted continuous kilns for the firing of certain products. In the heavy-clay industries, Hoffman, Belgian, Zig-Zag, Chamber and car tunnel continuous kilns have been introduced, according to the product being fired and the type of kiln favoured. In the pottery industry, the intermittent, coal-fired ovens are, to some extent, being replaced by continuous systems, chiefly the car tunnel kilns. According to the old method, coal firing on grates or on the dead bottom of the firehole was the only method of heating the kiln. Nowadays, the methods of heating are very varied, and include the use of coal firing on grates, mechanical stokers and mechanical coal feeders. Different types of fuels, such as producer gas, fuel oil and even town gas, in the case of the fine ceramic industry, find application. The fuels other than coal were made economically possible by the introduction of the continuous kiln.

Thus, in recent years, the smoke emitted during the firing operation by works in the clay industry has been reduced by the introduction of continuous kilns, the use of which is continually growing. The design and operation of the continuous kiln makes the firing practically smokeless when coal is fed by hand, whilst they render the use of gaseous and liquid fuels, which are smokeless, economically possible.

Thus it may be stated that generally it is the intermittent, coal-fired ovens which emit the smoke, and that by replacing them as far as possible by continuous kilns, the smoke emissions will be reduced to a minimum. But it should be remembered that, at the present time, not all intermittent kilns can be replaced by continuous kilns. Certain heavy clay products require special conditions of firing, such as kiln atmosphere, etc., which can be obtained by the intermittent kiln firing practice, but which have not, as yet, been successfully obtained in the continuous systems of firing. Again, continuous kilns can be and are used on the larger works for certain products, but the smaller works may not have the output necessary to keep this type of kiln in constant operation. These smaller works, distributed all over the country, usually possessing coal-fired intermittent kilns, should have the utmost consideration in the study and regulation of smoke emission as their problems are not easily solved,

In dealing with the smoke emissions from kilns, one must deal primarily with the coal firing of intermittent kilns. Fuels other than coal might be used smokelessly on this type of kiln, but, taken generally, no fuel other than coal is economically possible in this country. Coke, low-temperature coke, fuel oil, producer gas, etc., are fuels capable of producing smokeless combustion, but each is more costly than coal, whilst in some cases it is open to question whether correct firing of the product would result.

The firing of intermittent kilns is quite a different problem from that presented by continuous kilns, because the conditions under which the fuel burns in the two classes of kiln are very dissimilar. Smoke is definitely formed at certain stages of the operation in intermittent kilns. The firing with a coal of a high volatile content, fed by hand on the grates of such a kiln, is, itself, intermittent, and this fact, taken with the effects of very little or of cold secondary air, and the low temperature about the fire zone favours the production of unburnt smoke by the kiln. With the continuous kiln, the secondary air is preheated, the firing zone where the fuel is applied is always at a high temperature and the flames do not strike cold surfaces since the preheating zone of the kiln prevents this. Thus, in the continuous kiln, most of the factors for complete and smokeless combustion are present.

The emission of smoke from the intermittent kiln can, sometimes, be reduced, but it cannot be prevented. For instance, in the initial or water smoking period, the kiln, the grate, the goods to be fired, the stack and the air supply are all cold, conditions which are highly favourable to the production of smoke. Again, excess of air is required during this initial heating, for it is necessary that the goods be heated very gradually in order to prevent cracking. This, also, increases the yield of smoke. Indeed, the conditions at this stage of the firing approximate to those which prevail in the ordinary domestic grate. The use of a steam or semi-bituminous coal instead of a bituminous or high volatile content coal during the initial period will reduce the smoke emitted. The problems of smoke emission in the clay industry are, therefore, most particularly concerned with the firing of intermittent kilns with bituminous coal.

That the industry is well alive to the problems can be seen by anyone investigating the conditions. In the pottery industry, on the larger works, there are many indications that the tunnel kiln is displacing the intermittent kiln. In the heavy clay industries, certain products, such as, for instance, blue bricks and tiles, red, brindled and flashed roofing tiles, and salt-glazed pipes, due to some characteristics of the firing operation, can at the moment, be fired, most successfully, in intermittent kilns. These industries are receiving careful consideration. This is illustrated by the fact that the National Federation of Clay Industries has distributed such reports to its members, as "Abatement of Smoke Emissions from Kilns," by J. W. Mellor, D.Sc., F.R.S., and E. Rowden, B.Sc., D.I.C., A.I.C. (of the British Refractories Research Association). Further, E. Rowden has carried out other investigations on the smoke emissions from kilns for this Federation, which is doing its utmost to help by supplying information to manufacturers of heavy-clay products. As is shown later in the present paper, there is evidence that the grate design of intermittent kilns is being altered from the old designs, whilst patented "smokeless" kilns are being put forward. These improved designs should help to reduce the smoke emissions in the firing of certain products, but for other products many difficulties in regard to smokeless combustion are presented.

INTERMITTENT KILNS.

(a) Pottery.

Intermittent kilns are used in the pottery industry for the firing of china, earthenware and wall tiles in the biscuit and glost conditions, whilst intermittent coal-fired, muffle kilns are used for the firing of china and earthenware enamel ware. For the biscuit and glost firings, round bottle-neck kilns 15 to 20 feet in internal diameter, with a total internal height from kiln floor to crown of arch of approximately 20 feet, are used. The kilns are heated by means of 8 to 10 fireholes distributed round the periphery

of the kiln at the base. There are various types of these kilns, which work either on the updraught or downdraught principle, which means that the gases from the fireboxes either pass directly up through the ware placed in the kiln as in the updraught kiln, or else flow from the fire-boxes to the crown of the kiln and then pass directly down through the ware to the underfloor flue system as in the downdraught kiln. The ware is placed in fireclay containers known as saggars, the saggars being placed on top of one another often to a height of 15 to 18 feet. It can be realised that it is a difficult operation to heat ware distributed so widely throughout the oven to an even temperature, and that special methods of firing have to be adopted.

(b) Heavy Clay.

The main type of intermittent kiln used in the heavy clay industry is that known as the round down-draught kiln. The kilns are of various designs and sizes, but an average kiln would be about 25 feet internal diameter, 15 feet internal height from kiln floor to crown of arch, and would be heated by ten to twelve fireboxes distributed round the periphery at the base. This kiln would hold about 25,000 of 9 ins. \times 4½ ins. \times 3 ins. bricks, which is equivalent to approximately 100 tons of green ware set in the kiln or 85 to 90 tons of fired ware. The ware should be heated reasonably uniformly throughout to a certain maximum temperature. Not only this, but in order to produce a satisfactory product, the ware should undergo certain definite chemical and physical changes. In fact, the firing of clay goods is undoubtedly a complex operation.

Amongst the other types of intermittent kiln used are the rectangular downdraught kiln, the Newcastle kiln and the Scotch or open kiln, all of which are coal fired.

Reactions occurring in the Firing of Heavy Clay Ware.

The ware as made maybe firebricks or building bricks, may contain 10 to 20 per cent of mechanical water, according to the process of manufacture. The bricks may be set straight in the kiln or may first be dried on drying floors or in dryers. With poor drying the ware may contain 13 to 14 per cent. of mechanical water as set in the kiln; with average drying on a drying floor 5 to 6 per cent; with good drying, in specially designed dryers, 1 to 4 per cent; whilst dry-pressed bricks set straight in the kiln contain about 10 per cent. of mechanical water.

This moisture must be slowly evaporated from the ware if cracking is to be avoided, so that the heating must be very slow up to 200° C., and not until all the water has been removed from the goods must the rate be increased. This water-smoking period may extend from two to three days up to a fortnight, varying, of course, according to the percentage of water in the ware as placed in the kiln and the nature of the clay. The elimination of this mechanical water is one of the most important operations in the firing of clay wares.

The chemically combined water in the clay, which may amount to 10 per cent., is driven off between 400° and 650° C. This reaction must be completed before the next stage commences, as in this stage an oxidising atmosphere is desired and the presence of steam in the kiln prevents this to some extent.

Very important reactions occur between 600° and 900° C. Any carbonaceous matter present in the clay has to be burned out, and any iron present oxidised to the ferric condition, if good ware is to be obtained. Both of these reactions require the presence of an oxidizing atmosphere, so that excess air is required in the kiln during this stage of the firing, whilst time must be allowed for the reaction to proceed. As soon as all the carbonaceous matter has been burnt out and the iron oxidised, the temperature can be raised rapidly to the finishing temperature, which, of course, varies with different products. Building bricks are usually fired to 950° to 1100° C. (approx.), whilst firebricks reach a maturing temperature varying from 1200° to 1400° C.

Thus for claywares generally the heating can be divided into three stages ;—

- (1) The slow heating of water smoking period up to 250° C.
- (2) The combined water and oxidation period—400° to 850° C.
- (3) The full firing, maturing or vitrification period, from 850° C. to the finishing temperature.

In the case of blue, brindled and flashed bricks and roofing tiles, a reducing atmosphere is necessary during the final stages of the firing operation. In the case of salt-glazed ware, the "salting" of the kilns takes place during the full firing period.

Comparison with Boiler Firing.

The firing of a kiln full of clay ware is entirely different from that of a boiler. In the firing of a boiler, the object is to obtain the maximum amount of heat possible within the boiler. The heat can be generated intensely and efficiently with the minimum of excess air to give complete combustion. It should, of course, be transmitted efficiently to the water, and the life of the refractory materials of the combustion chamber should not be seriously reduced. No evenness of temperature throughout the length of the boiler tubes is required, and the gases have not to be specially oxidising or reducing, but can be so adjusted that combustion is complete, which factor, however, with hand-fired boilers usually entails a 20-50 per cent. excess of air. In fact, the higher the temperature of the fuel bed the more efficiently is the heat transmitted since radiation plays a great part in the heat transference.

But entirely different conditions have to be satisfied in the firing of a kiln full of clay goods. In general, it is the requirements of the goods which have to be considered more than the efficiency of combustion. In heating a kiln, it is not possible to burn the fuel rapidly, and efficiently, as the rate at which the temperature increases must be regulated to suit the changes taking place in the contents of the kiln. The ware has to be heated up according to a definite time-temperature schedule, whilst the kiln atmosphere has to be varied according to the stage of the firing and the type of ware being fired. Further the heat has to be transmitted evenly to the whole mass of goods set within the kiln and at the end of firing, all the goods should have attained practically the same maximum temperature.

During the water-smoking or slow heating period up to 250° C., the ware is really heated by hot air produced by drawing an excess of air over small fires maintained in the fireholes.

In a boiler the heat is practically all generated in the firebox, is radiated and conveyed direct to the metal and water. If combustion is delayed, the gases strike cold metal surfaces with the resulting chilling of the flame, checking of combustion and the formation of black smoke. However, in the last stage of heating of the goods in a kiln, the object is to produce combustion amongst the goods themselves, so that thick fires are maintained in the fireboxes and the combustible gases produced are burnt with secondary air amongst the hot ware. Thus heat transference is direct from the flames to the goods, instead of the heat being generated locally in the fireboxes away from the goods. Long flame, bituminous coal is preferred for this purpose. Delayed combustion is possible at this stage since the goods are at a comparatively high temperature.

A further Consideration of the Firing of Heavy Clay Products.

(1) Water-Smoking Period.

In the first stage, a temperature just sufficient to evaporate the moisture from the goods is required and small fires are essential, the firegases being considerably diluted with air. The moisture must be evaporated slowly in order to prevent cracking of the ware, so that only very small fires are used and the temperature within the kiln is gradually raised to 200° to 250° C.

Small fires of two or three shovelful of coal are gradually built up on the grates and all firedoors, etc., are left full open and the stack damper full out, so that plenty of cold air is drawn over the fires. Thus, the ware is actually dried by means of

warm air. Everything is more or less cold and the goods may be wet. On making up the fires, the volatile matter distils off and is only imperfectly burned since the temperature is not high enough to promote the combustion of the volatile gases with the air, i.e., it is below the ignition temperature. The only means of preventing smoke is to fire small quantities of coal at a time, so that the evolution of volatile matter is small.

Thus smoke will be evolved during this period, after each baiting, and once 100°C . or so has been reached in the kiln, a white haze of water vapour will also be given off. Naturally the length of the water-smoking period and consequently the amount of smoke produced can be reduced by setting only thoroughly-dried ware in the kiln. But in the manufacture of certain heavy clay products there are often difficulties in the way of setting dry ware in the kiln. Wet ware is often set owing to the friable and tender nature of the thoroughly-dry ware. Where products have to be handled many times in the setting operation, thoroughly-dried ware will lead to chipped and broken products.

An idea of the amount of steam to be driven off can be obtained from the following figures. A 25 feet diameter kiln will hold approximately 100 tons of green ware, so that if this ware contains 5 per cent. of mechanical water, the weight of water to be driven off is 5 tons. This can be considered as equivalent to a volume of steam about 80 times the internal volume of the kiln or 200 times the volume of the fired goods.

(2) Combined Water and Oxidation Period.

Once the water-smoking is completed, the firing of the kiln can proceed more rapidly. The fires are gradually built up so that the temperature rises at a steady rate, but air still passes over the top of the fuel bed, although by this time the grate itself is completely covered with fuel. The stack damper is still full out and the top firing doors fully open. The air serves to carry the heat to the bottom of the kiln, and tends to prevent uneven heating. During this period up to 600°C ., the chemically-combined water in the clay is being driven off. Thus from 200°C . to 600°C ., conditions within the kiln are relatively cool, so that combustion of the volatile gases derived from the coal is incomplete, especially just after each firing, so that smoke is still formed even in the presence of excess air, mainly due to the low temperature, which is below the ignition temperature of the combustible gases. Water vapour is also being evolved from the stack, being derived from the chemically-combined water in the clay, which varies from 5 to 12 per cent. according to the composition of the ware.

The fires are built up fairly quickly until the temperature reaches 600°C ., but during the oxidation period from about 600° to 850°C ., a more gradual and soaking heat has to be applied, air being admitted over the fuel bed. This air gradually burns out the carbonaceous matter in the ware and if much of the latter is present, as is sometimes the case with clay used in the manufacture of building bricks, a "blue" smoke will be produced. It is essential that excess air should be present during this period. By this time the fireholes will be practically filled with fuel, with the exception of a 3 to 4 in. space over the top of the fuel bed, through which the excess air is drawn.

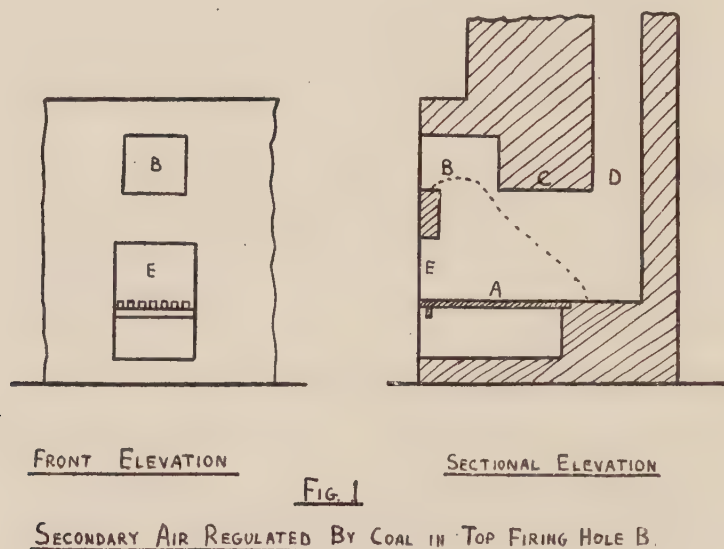
(3) Full Firing, Maturing or Vitrification Period.

As soon as all the carbonaceous matter has been burned out and the iron compounds, etc., oxidised, the temperature can be raised quickly from 900°C ., to the finishing temperature which, as already stated, will be approximately 950° to 1100°C . for building bricks, 1200° to 1400°C . for firebricks. It is during this period that maximum rates of combustion are obtained. Often poor classes of coal are used during the first two stages of heating but good-quality coals, and often, long flame bituminous coals are used for the final heating.

During this stage of the firing, the top firehole is completely filled with coal, and with certain designs of firehole, the height of this coal and the degree of packing control the amount of secondary air which is drawn in. This leads to variable conditions

of combustion, dependent on clinker formation and the production of crusts of coke. A crust of clinker over the firebars limits the passage of the primary air through the fuel bed and less producer gas effect is obtained. The rate of combustion is decreased and, at the same time, as the air cannot enter through the bars more is drawn in over the fuel bed. Again, a crust of coke forming over the firing hole will cut down the amount of secondary air which can enter.

The drawing of a firehole is shown in Fig. 1. From this drawing it can be seen that the coal will gradually build up on the firebars during the progress of the firing operation until, in the full firing period, this coal tends to close the top firing hole B.



During the oxidation period, air is drawn in through the space between the top of the fuel bed and the drop arch C. During the final heating period this opening is completely closed with coal and the necessary secondary air has to draw through this coal. As stated above accurate control of this secondary air is not possible. In the slow firing or water-smoking period all spaces are left open. After water-smoking the opening or glut E just above the grate is partially closed with bricks thus reducing the front area. The trouble with this and several other types of firehole is that the primary and secondary air are not under accurate control.

Effective firing during the full fire period depends on the attainment of a sufficiently high rate of combustion by means of the primary air. The temperatures in the fuel bed are the highest and the tendency for clinker formation the greatest, so that the fires should be kept clean of ash. The cleaning of the fires should be carried out carefully. During this period, the fires should be cleaned out two or three times daily, the frequency depending on the quantity and quality of the ash in the coal. All the fires should not be cleaned out in rapid succession—it is better to clean alternate fires and then to do the others four hours or so later. After cleaning, the fires should contain enough red-hot fuel to form a fresh basis for the charge of green coal next put on. The fires should not be filled up immediately with green coal, as this will produce large volumes of smoke both on account of the large amount of coal put on and consequently the large volume of volatile gases evolved, and also on account of the fireboxes being cooled by the large amount of cold air drawn through during the cleaning operation. By charging the cleaned fires lightly with coal and then urging carefully with fresh light charges at intervals, the fires rapidly regain the heat lost without great smoke production.

The fires should always be well cleaned at the beginning of the full fire period and, during this stage, should be urged steadily. To secure a uniform temperature from top to bottom of the kiln, it is necessary to burn some the gases inside the kiln in addition

to those burned in the "bags" or combustion chambers. This is accomplished by admitting air over the top of the fuel bed or through separate openings into the kiln. This secondary air, if properly controlled, will cause the production of long gas flames which extend well down among the goods and heat them more or less uniformly with the production of little smoke. Often, however, the grates do not possess such secondary air inlets, and in such circumstances, a different method has to be applied whereby the heat in the "top" goods is carried down into the middle and lower part of the kiln. To do this the fires are charged heavily with fuel so as to produce plenty of heat (though not too much) in the "top" goods. As the fires die down, air passes over the fuel beds into the kiln and carries the heat from the "top" goods to those lower down. This is known as "heating in waves." Care is needed not to allow so much air to follow the fire gases that the goods become too cool. By this method all the ware is brought to the finishing temperature at the same time, but heavy smoke is produced each time the kiln is "baited."

Analyses of the waste gases from a kiln show that, after refuelling, the amount of excess air is a minimum or is insufficient, but gradually increases as the volatile matter is distilled off from the fresh charge. There is, therefore, a periodicity in the conditions of the kiln due to the changing conditions in the firemouth. The more frequent the baitings the smaller the variation in the amount of excess air required at different times.

In firing, a large charge of green coal may be thrown on a glowing fire, and hydrocarbons are distilled off in great quantities. These hydrocarbons will burn in the bags if air is present and if the temperature of the fire has not been lowered below the ignition temperature by the charge of cold coal and the inrush of cold air over the fire. As fired, however, they pass over into the kiln and if the firing is in the early stages, they never reach their ignition temperature and go out of the stack unburned. If the firing has advanced a little, the kiln and setting may be reasonably hot and the gases reach their decomposition temperature, being broken down into carbon and hydrogen. The hydrogen mixes with the air readily and is burned. The carbon, being a solid, does not so easily find its requisite oxygen, and part of it passes out of the stack as unconsumed smoke. This may happen when the kiln is at a white heat if there is a deficiency of air, or if, owing to the improper design of the kiln, the air fails to mix with the combustible.

Firing at intervals of two hours or so and completely filling each furnace with coal, therefore causes the rich gases to roll into the kiln in clouds, and it is impossible to supply enough air to cause them to burn. Thus fuel is wasted and smoke produced. The effect is increased by the lowering in temperature in the firebox due to such a large cold charge of coal being placed therein, and it takes, at least, fifteen minutes before the fires are working efficiently again. Smoke in a downdraught kiln can only be reduced by admitting air behind and above the fire, and by extremely careful firing. When smoke has once formed it can seldom be properly consumed, and the only correct procedure is to try to avoid its formation by admitting a suitable amount of secondary air to the firehole.

It is often very difficult to prevent smoke in the final stages of heating, especially with high temperature firing at 1300° to 1400° C. The fires have to be forced and in order to obtain this high temperature the supply of air must be cut down almost to that required theoretically, otherwise the temperature will never be reached.

In boiler firing it is found best to fire small amounts of coal at frequent intervals in order to obtain efficient combustion and to reduce smoke formation. But in spite of the theoretical advantage in fuel economy from firing "little and often," and using a thin fuel bed, practical considerations in the heat distributions in kilns indicate that full fires during the latter part of a high temperature burn are more efficient, in fact, are necessary. By using thick fires and long flame, bituminous coal, producer gas effects are produced and the heat is generated in contact with the goods.

IMPROVEMENT IN KILN GRATE DESIGN IN THE HEAVY CLAY INDUSTRY.

(a) Old Design of Firehole.

As already stated, in a round down-draught kiln the coal is burnt in a number of fireboxes, around the periphery. maybe ten or twelve in number, the coal being placed on flat or inclined grate bars or on the solid bottom of the firebox as in the dead bottom type.

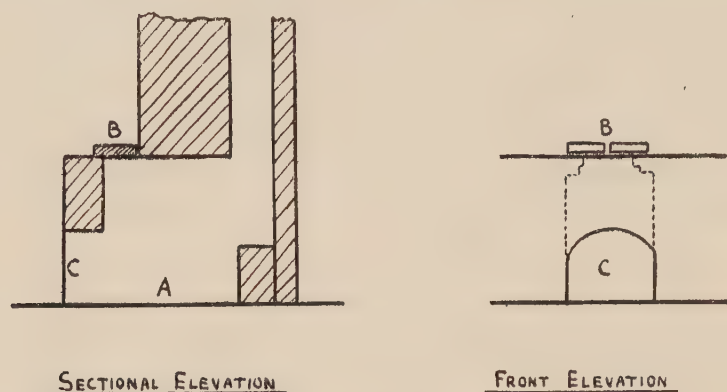


FIG. 2

HOB-MOUTH, DEAD-BOTTOM TYPE OF FIREMOUTH.

Figs. 1, 2 and 3 illustrate the old designs of firebox, and it will be noted that there is practically no control of the primary and secondary air supplies.

Fig. 2 shows the hob-mouth, dead-bottom type of firehole, a type that is largely used in the firing of roofing tiles. In the firing of this product in the intermittent kiln the ware is set in the leatherhard condition, i.e., containing 12 to 14 per cent. of mechanical water. A long water-smoking period of three weeks or so is necessary, the remainder of the firing operation taking about seven days. During the water-smoking period very small coal fires are maintained on the floor of the firebox, and the fires more or less smoulder and give rise to smoke both out of the fireholes and out of the stack. In the real heating stage, the coal is fed in by removing the quarries at B, and the fireboxes are quickly built up with coal up to this opening B. The ashes accumulate at the bottom

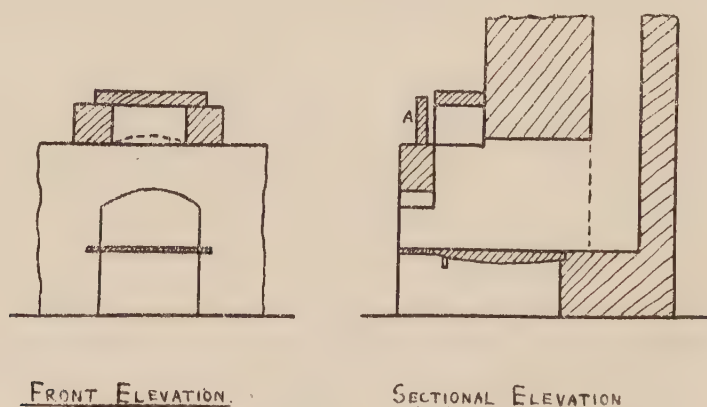


FIG. 3.

SECONDARY AIR REGULATED BY MEANS OF A QUARRY A.

A and in time clinker up. A hole is then punched through the clinker at the glut C, so that primary air can still be drawn through the fuel bed. Often the quarries at B are kept closed over the firehole, in which case no secondary air can be drawn in, so that the fires are very liable to produce heavy black smoke. This type of firehole is possible, for in the firing of roofing tiles rapid heating is not required whilst the maximum temperature of firing is only about 1100° C. For blueing, when a reducing atmosphere is desired, this type of firehole is excellent, for by heavy firing and keeping the opening at B closed, so cutting out any secondary air, intense reducing conditions can easily be produced, but with the consequent formation of heavy black smoke.

For more rapid firing and better combustion, grate bars are utilised. The grate bars vary according to the class of coal being used. When a coal, which lies lightly on the bars forming a porous bed through which the primary air can readily pass and afford sufficiently rapid combustion, is used, it is convenient to have a flat horizontal grate. For poorer qualities of coal, with high or fusible ash contents, which require a larger grate area in proportion to the depth of the firehole, grates inclined at an angle of about 45 degree are better. These sloping grates are easier to clean than flat ones, so that the clinker or ash can be more readily removed, and the larger grate area allows a sufficient quantity of the poorer coal to be burnt to obtain the required number of heat units. For a particularly difficult fuel such as dross or slack, the grate may be arranged in a series of steps fixed across the fireplace, with a space of 1 to 2 inches between each. The uppermost step is at the front of the fireplace and the following steps recede until the lowest one is reached (see Fig. 5).

Whatever type of grate is used, it should be so constructed as to furnish a steady, uniform distillation of the volatile products of the coal and a steady combustion of the fixed carbon of the fuel. A kiln grate is not designed to complete combustion of the fuel charged upon it during the high temperature period. Its true function is to convert the coal into a gas which can afterwards be burnt by the supply of secondary air. The sole purpose of the primary air should be to effect this gasification of the fuel with a minimum waste of heat in the firebox itself.

In baiting sloping grate furnaces, it is better not to throw the coal directly into the firebox. The proper method is to place the new coal on the top of the fuel bed at the firing door where it can coke and later be pushed down over the fire.

(b) The Combustion Chamber.

To secure efficient combustion, the flames and other products from the fire are passed through a combustion chamber in which they will be maintained in an incandescent state until combustion is sufficiently complete before the flames become unduly cooled by contact with the goods. In down-draught kilns this usually takes the form of a rectangular "bag" of firebrick built round each firehole, and varying in height from about three feet up to the springer of the kiln which may be eight feet or more. Such "bags" must be large enough to permit the firegases to be efficiently burned and must deliver the gases to the proper part of the kiln. A height of 4 to 5 feet usually gives the best heat distribution. During the early stages of heating the bag walls aid proper combustion by providing hot contact surfaces near the fires.

(c) The Causes of Smoke.

The formation of smoke in intermittent kilns is due to the fact that bituminous coal is used, and that on firing with coal large volumes of combustible gases are rapidly given off, especially when large amounts of green coal are fired at once. It is usual for the fireman to bait each firehole on a kiln heavily with coal, and often to fire several kilns together. Smoke is produced by the incomplete combustion of the volatile components of the coal, the incompleteness of combustion being due to the following reasons:—

(1) Insufficiency of air to complete combustion together with poor admixture of this air with the gases.

(2) The temperature in the furnace is too low to ignite the gases.

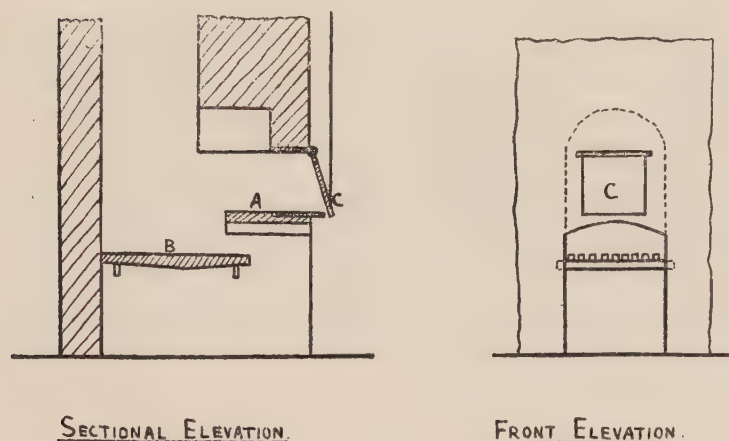
(3) Sudden cooling of the gases below the ignition temperature before combustion is complete.

Thus not only should sufficient air be provided to burn the gases, but it must also be well mixed with the gases, whilst the temperature must be maintained above the ignition temperature of the combustible gases, i.e., above 600° to 700° C. Thus in the firing of an intermittent kiln below 600° to 700° C., smoke will be produced, as the temperature is not sufficiently high to burn the volatile gases. During the high temperature period of firing, smoke emission can, in some cases, be reduced by admitting secondary air and paying careful attention to the methods of firing the coal.

(d) Methods of Firing and of admitting Secondary Air in order to reduce Smoke in the High Temperature Period, together with more recent Designs of Fireholes.

As previously stated, practical considerations concerned with the heat distribution in kilns indicate that full fires during the latter part of a high temperature burn are the more efficient from the standpoint of producing satisfactory products. By using thick fires and long flame bituminous coal, producer gas effects are produced and the heat is generated in contact with the goods.

In order that thick and heavy fires may be used and at the same time efficient combustion obtained, the following method can be used, provided the kiln has reached red heat, i.e., is hot enough to maintain the combustible gases above their ignition temperature: Fire alternate furnaces at each firing and bait heavily, the necessary hot air for combustion being admitted through the furnaces not baited in which the fires are low. The maximum advantage is thus taken of any producer effect obtained with heavy fires, and at the same time enough air is admitted through the remaining fires to keep the loss of combustible gases through the stack at a minimum. With heavy fires judgment must be used in determining the firing interval, so that the combustible left unburnt in the ash shall be low and yet the fires not allowed to burn so low that the kiln is cooled. Heavy fires are not advantageous before the ware is at a red heat, and with light fires there is no reason for alternate firing. Thus by firing little and often until the kiln is hot, and then by firing alternate furnaces, smoke emission may be reduced.

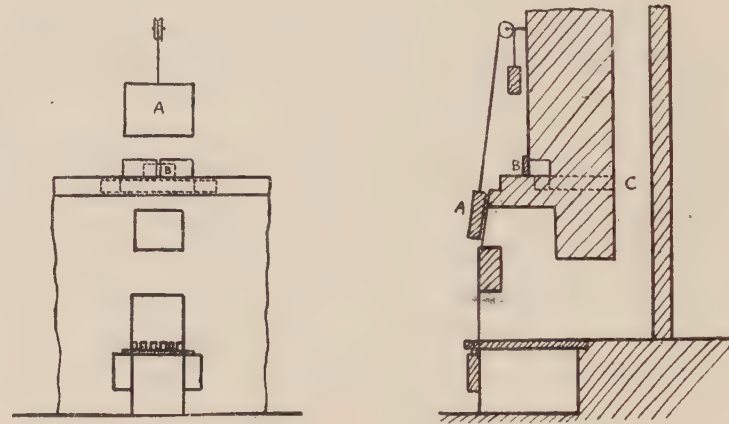


SECTIONAL ELEVATION.

FRONT ELEVATION.

FIG. 4.

FURNACE DESIGNED TO REDUCE SMOKE EMISSION.
LOKING PLATE METHOD.



FRONT ELEVATION

SECTIONAL ELEVATION.

FIG. 5.

FURNACE FITTED WITH ADJUSTABLE FIREDOOR A, AND SECONDARY AIR INLET B.

In some plants it is the practice to commence heating with a poor class of coal and then to use a better class of coal to obtain the final heat. For the preliminary heating a low volatile coal is best if smoke formation is to be minimised, but a long flame bituminous coal is desirable in the full-fire stage to give a more uniform heat distribution in the ware. Its use should begin as early as possible, but not before the kiln is at a good red heat, since this coal is liable to smoke badly. For this class of coal, to avoid excessive smoke, the coal should be fired on a clear space at the front of the grates from which the cokes have been pushed back. The two chief factors governing the formation of smoke under the above conditions are the method of firing the coal and the design of the firebox. If the coal is allowed to coke on a clear grate surface with a good supply of air passing through it, the volatile gases evolved will, at once, be mixed intimately with air enough to ensure quick and complete combustion when they are further heated and ignited. Judicious admission of secondary air over the fuel bed at the front of the furnace will aid smoke reduction. At many plants the only means of controlling the admission of secondary air over the fuel bed is to close the firing opening with a thick

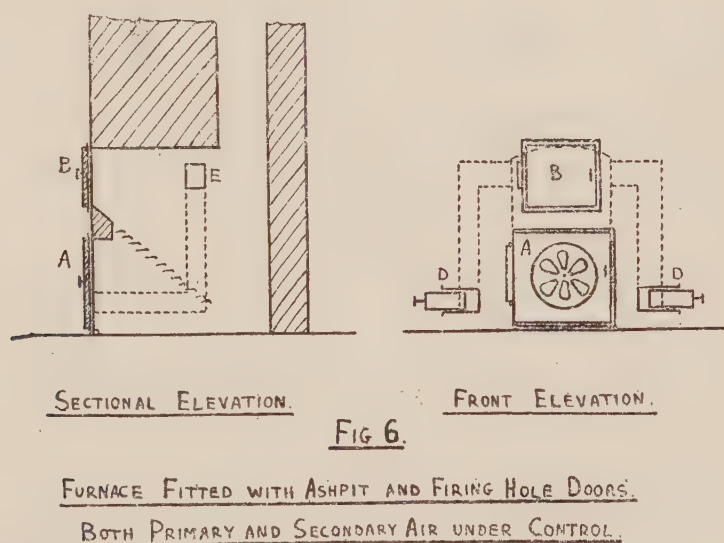
bed of coal. It would be better practice to control the secondary air with furnace doors, especially during the early stages of heating.

Fig. 4 shows a furnace, designed on the above principle, to reduce smoke emission (U.S. Bureau of Mines). At each firing, coke from the coking plate, A, is pushed back until it falls on to the grate, B. All fresh coal is then placed on the coking plate, where it is coked by radiation from the hot arch. Immediately after firing, air is admitted over the fresh coal by opening the firing door, C. If the door is hinged at the top, air enters at the bottom and comes into intimate contact with the coal in passing through into the firebox.

The admission of Secondary Air.

During the full-fire period, the completeness of combustion depends on the admission of secondary air. Usually this air is admitted in front of and above the fuel bed through the top firing hole as shown in Figs. 1, 3 and 4, the only difference between the methods being that the air is regulated in Fig. 4 by means of the top firing door. In the open type, Fig. 1, the secondary air draws either over the fuel bed or through the fuel bed at the top firing hole, B, mixes with the gases in the firebox, passes along the drop arch, C, and then into the bag, D. A certain amount of mixing results and the gases burn as they rise up the bag into the kiln. The objections to this method are that the air is often admitted in a single stream of large cross section and that it is difficult to regulate the amount of air admitted. By using doors, the amounts of air drawn in during the early heating periods can be better regulated, as can also the secondary air during full firing.

A better arrangement is shown in Fig. 5. The top firing hole is covered by means of a firebrick door, A, which can be raised or lowered thus admitting air if required. A small opening, B, 9 ins. \times 4 ins. above the top firing hole is subdivided, thus giving two flues which lead directly through the kiln wall to the bag, C. During full firing, secondary air is allowed to draw through these and mix with the combustibles in the bag. The entrance, B, to this opening is closed by means of two bricks placed end to end. By separating these the area of the opening can be regulated. Secondary air can thus be admitted and regulated in two different ways.



Another method is illustrated in Fig. 6, in which both the primary and secondary air are under direct regulation, although the draught on the kiln will vary the amount of air drawn in. A stepped grate furnace is shown, the secondary air being passed through two flues, D, one on each side of the firehole, where it is preheated to some extent, before entering the firehole above and behind the fuel bed at E. The openings to these two flues can be controlled by means of shutters. The top and bottom fireholes are closed by means of iron doors, the bottom ashpit door, A, being provided with a series of holes regulated by a circular shutter, this being the means of controlling the primary

air. If, for any reason, more secondary air is required than can be admitted through the openings provided, this can be allowed to enter over the fire by opening the top door B.

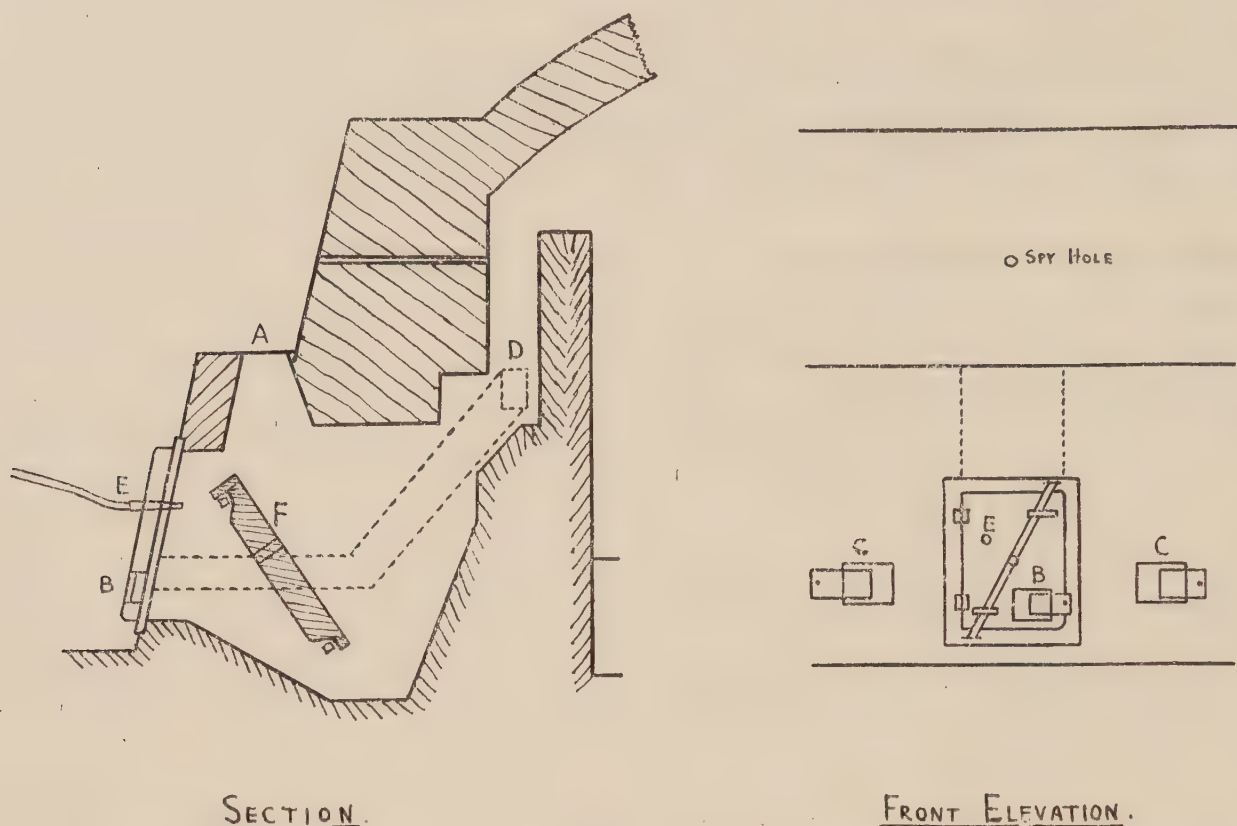


FIG 7.

GAS PRODUCER TYPE CONTROLLED PRIMARY AND SECONDARY AIR.

Fig. 7 shows a very similar design, using gas producer principles, and definitely controlling the supplies of primary and secondary air. It is known as the hob-mouth type, the fuel being fed in at the opening, A. When the kiln is on full fire, this opening is kept completely filled with coal, so preventing the entrance of air through this charging hole. The ashpit is completely closed by means of an iron door, an opening, B, and shutter slide in this door controlling the supply of primary air. The secondary air is admitted, through the two slides, C, and thence by flues which run alongside the firemouth, so preheating the air until it is discharged amongst the combustible gases at the exits from the firemouth at D. By opening or closing the secondary air slides, oxidising or reducing conditions can be obtained in the kiln. It has been stated that, with this type of grate-fired kiln, it is possible to obtain reducing conditions with very little less than the amount of air required to produce complete combustion, and thus, although it may not be possible to eliminate smoke, it is possible to effect a reduction in smoke emission even in the burning of blue bricks. If this claim is correct, then some of the black smoke emitted during the reducing period in the firing of blue goods would be prevented. But smoke would still be emitted from the kiln when at a temperature below 600° to 700° C., due to the temperature being below the ignition temperature of the volatile coal gases. A further point about this grate is that during full fire, water is allowed to drip under the fire, being admitted by the nozzle, E. This serves two useful purposes: firstly, it cools the ashes and the steam formed reduces the tendency to clinker formation on the bars, and secondly the steam reacts with the incandescent coke producing hydrogen and carbon monoxide, both of which are combustible gases. Also it should be noted that the above reaction forms gases which may produce a reducing condition without smoke. The grate, F, is inclined at a steep angle and the firehole so arranged that the coal falls freely and does not stick or bridge across. The fuel used consists of rough slack or nuts, preferably a coal high in volatiles. During the early stages of firing the fuel is burnt in small quantities on the bottom of the bars, all air

being controlled through the primary air slide. During full fire the fuel should never be allowed to burn too low, or the charging hole, A, would become open and upset the required conditions.

From the foregoing it can be seen that, in the firing of certain products, by using secondary air, as illustrated in the recent designs of fireholes, the smoke emissions during the high fire period (i.e., in the case of products firing to about 1000° to 1100° C.) can be reduced, especially if, at the same time, care is taken in the method of firing the coal. The latter factor often entails extra labour for the fireman.

The burning of various Products.

As stated previously, the firing of a kiln is governed by the nature of the goods being fired. The foregoing deals mainly with the firing of fireclay goods, red building bricks and red roofing tiles, and for these the three firing periods, i.e. water-smoking, oxidation and vitrification periods are necessary, together with the conditions entailed therein.

For silica goods, the water-smoking period is short. Nevertheless, the goods should be heated slowly up to temperatures of 650° C, particularly between 500° and 650° C, owing to changes in the silica, which result in volume alterations. Cracking would occur with rapid initial heating. Silica goods are fired to high temperatures of cone 14 or over, that is about 1400° C or over. In order to obtain this temperature, the fires must be forced towards the end, and excess air must be limited to obtain this high temperature. Often heavy firings over hourly intervals are employed, so that smoke will be produced during this final period. The heavy firings also help to heat the goods set away from the fires. The atmosphere within the kiln does not matter to any great extent and usually alternate reducing and oxidising conditions are produced owing to the method of firing. It is essential that the setting of silica bricks be cooled very slowly.

For firing red building bricks, red roofing tiles, and terra-cotta, an oxidising atmosphere is required throughout the whole burning, and often more than double the theoretical amount of air needed to burn the fuel is necessary if blueing or flashing of the goods is to be avoided, and a good red colour obtained. Common building bricks often contain a large quantity of carbonaceous matter which has to be burnt out during the oxidation period, in order to prevent black cores and discolouration of the bricks, so that plenty of excess air has to be provided at this stage of the heating.

Other classes of ware require treatment directly opposite to the above, requiring at a certain stage in the firing a strongly reducing atmosphere. Thus, blue bricks and pavers and blue roofing tiles require a reducing atmosphere at a certain stage in the firing, whilst brindled, flashed and mottled building bricks and tiles require alternate oxidising and reducing atmospheres during a certain period. During the reducing stage, volumes of black smoke are evolved. No successful methods of obtaining these products satisfactorily and economically, in the intermittent kiln, without the emission of smoke have, to the author's knowledge, been put forward. Consequently, the production of smoke would appear to be part of the manufacturing procedure. It should also be mentioned that there are conspicuous difficulties in the design of continuous kilns to give the requisite conditions for the production of blueing effects.

Let us consider the case of the burning of blue engineering bricks. The blueing must be carried out under strongly reducing conditions at the finishing stage of the burning, the preceding stage being oxidising. The goods should be heated to 1100° C before starting the reduction, whilst the finishing temperature may be 1250° — 1300° C. Thus up to 1100° C the bricks need the same firing as ordinary red bricks, in an oxidising atmosphere in order to burn out carbonaceous matter. To obtain the blueing, usually twelve to twenty-four hours or more of strongly reducing conditions are required. To secure effective reduction, the coal used must be a free-burning one with a high percentage of volatile matter. When about to start reduction, the fires should be cleaned and allowed to burn bright. The draught is then reduced as far as can be

safely done by lowering the kiln damper, and the fireboxes filled with as much coal as they can carry and yet continue to burn. All air inlets to the kiln are closed except the ashpit, since some air must be admitted to enable the fuel to burn. A considerable volume of smoke will issue from the stack. After half-an-hour or more, the atmosphere in the kiln is clearer, and signs of a reducing atmosphere disappear. It is then necessary to stir and poke the fires so as to make them burn brightly, and as soon as possible to refill them with coal. This procedure is continued until the required amount of reduction as judged by trials is obtained. All the openings into the kiln are then closed and sealed with clay paste. During the first stage of cooling all air must be kept out of contact with the goods. The fires should be baited heavily just before the kiln is sealed completely and the chimney damper partially closed.

Brindled bricks and roofing tiles must be burned under oxidising conditions until firing is almost finished, but the end of burning must be effected under reducing conditions as for blue bricks, except that these conditions need not be quite so severe. The reddish colour in brindled goods is due to the reduction of the iron oxide being incomplete. Often these brindled bricks are produced in the manufacture of blue bricks. If the vitrification has not proceeded too far, and the atmosphere of the kiln is changed to an oxidising one by the admission of air, some of the iron will be oxidised to the ferric condition, which is recognised by the red colour, so that a product of mixed blue and red colour is produced. Thus, if air is admitted during the cooling period of blue brick firing, some brindled goods will result.

Flashed bricks and tiles are produced similarly, the goods being finished in a series of reducing atmospheres which are produced by heavily baiting the fires towards the end of the firing process.

In the burning of salt-glazed pipes, the pipes should be heated in an oxidising atmosphere until signs of vitrification just commence. By this means carbonaceous matter is burned out and the iron oxidised, which prevents blistering and pinheads later on. The initial part of the burn is similar to that of fireclay goods. When a temperature of 1040° — 1100° C is reached, and vitrification has just started, the fires are allowed to burn bright, salt is then thrown on to the fires and backed up with green coal. During the salting period, a slightly oxidising atmosphere, that is one with slightly more air than is necessary to burn the coal completely, is used. A very oxidising atmosphere tends to produce light-coloured ware. On the other hand, a smoky flame darkens the colour, dulls the glaze and brings the iron to the surface. Thus a clean kiln atmosphere is necessary for good glazing with salt. Owing to the harmful effects of salt vapour on refractories, and the difficulty of salting with continuous kilns, salt glaze pipes are, generally, fired in intermittent kilns.

In the pottery industry, where the ware is set in saggars throughout the large internal volume of the kiln, the practice of heating in waves is usually adopted. The fires are allowed to burn down and are then baited heavily. These alternations serve to carry the heat from the hotter to the cooler goods. It can be seen, however, that it is conducive to smoke formation at the times of baiting. The firing of these kilns is a difficult operation, for the admission of the air and the working of the fires controls the direction in which the heat travels, i.e. with an updraught kiln the heat may pass up the bag or under the floor to the centre well hole. However, it should be stated that for most pottery ware an oxidising atmosphere is desired. For the production of bone chinaware, a considerable excess of air is required in order that the ware may have the required whiteness and be free from discoloration.

Practically all blue Staffordshire bricks, blue-brindled and red roofing tiles and salt glaze pipes are burned in intermittent kilns fired with bituminous coal, whilst this is also the case for silica bricks with one or two exceptions.

From the above examples it is seen that the atmosphere within the kiln is largely governed by the nature of the ware to be fired. Smoke emission is also dependent, in some measure, on the products being manufactured.

Resume on the Reduction of Smoke Emission in the Firing of Intermittent Kilns.

(1) During the initial stages of heating it is best to fire little and often. Smoke is bound to be produced on firing owing to the furnaces, the kiln and the ware being cold and chilling the flames before combustion is complete. This is reduced to some extent by firing little and often and by the provision of bag walls and combustion chamber which provide hot contact surface.

(2) When possible the water smoking period should be reduced to a minimum by thorough drying of the goods before setting in the kiln.

(3) During the full fire period, several methods of firing are used :—

(a) Firing “little and often,” if possible, will tend to prevent the formation of large volumes of smoke.

(b) Baiting alternate furnaces every hour, those fires not baited being loosened and broken up. This means that a series of fireholes are fired every 30 minutes. With a very bituminous coal this time may be reduced to 20 minutes, firing less fuel at a time. Thus, the smoke produced from the baited fires will be mixed with hot air drawing in over the other fires.

(c) The method of heating in waves, whereby the fires are baited heavily and then allowed to burn low, will lead to smoke formation.

If possible, the fires should not be allowed to burn down too low before recharging, since the heavy charge required for filling up the furnace will lead to the evolution of large volumes of volatile gases and smoke.

(4) It is essential to admit secondary air to the fires when and where necessary, in order to burn the volatile gases produced from the coal. Secondary air is best regulated when the furnace is fitted with a door over the top firing hole. The admittance of the secondary air varies according to the design of the firehole and method of firing. When firing alternate furnaces, this air draws over the low fires, where it is heated, and burns the volatile gases from the furnaces just fired, inside the kiln. If all the furnaces in a kiln are fired at once, better results may be obtained when the secondary air is drawn over the fuel bed by allowing the secondary air door, i.e. top firing door, to remain open for five minutes or so after firing. If no top firing doors are provided, it is good practice to leave fires tolerably open over the fuel bed while they are freshly fired, and then partly close them after they have burned a little by adding a little more coal.

(5) If very “smoky” coal is used, the coking plate type of furnace, as shown in Fig. 4, will probably give better results and reduce smoke; alternatively one of the more recent designs of firehole provided with special secondary air flues may be used.

(6) When firing, it is better not to throw the coal immediately into the firehole. The new coal should be placed on the top of the fuel bed near the top firedoor, where it can coke in the presence of secondary air. On refiring, this coke can be pushed down over the fire and the top again made up with green coal. This method applies particularly to the sloping-grate furnace and to the coking-plate furnace.

(7) It is not good practice to clean all the fires in rapid succession. By cleaning the ashes from alternate fires every six hours (approximately) during the full fire period, a good supply of primary air is ensured, although this time interval naturally depends on the ash content of the coal.

(8) On cleaning, enough hot incandescent fuel should be left in the firehole on which to build up the fresh coal. After cleaning, the fires should be gradually rebuilt with fresh coal, urging the fires carefully so as to regain the heat lost by cooling during the cleaning process. By firing fresh coal on the front of the grates, the gases arising therefrom are well mixed with air, and pass over the hot coke at the rear, thus reducing the tendency to smoke formation. With sloping grates the ashes are easily removed from the space below the bars and can be removed at the times of firing.

(9) For the firing of certain classes of ware, such as blue bricks and tiles, in the

intermittent kiln the production of smoke is practically essential and is deliberately made during the last stage of firing.

CONTINUOUS KILNS.

Continuous kilns are of various designs, e.g. top-fired Hoffman kilns, grate fired Belgian kilns, gas or coal fired chamber kilns and tunnel kilns. Most continuous kilns are practically smokeless in operation, due to the conditions of combustion being more nearly correct, as for instance the high temperature around the firing zone and the use of preheated air.

Hoffman Kilns.

With top fired Hoffman kilns the coal, usually in the form of rough slack, varying in size from fines up to $\frac{1}{2}$ in. pieces, is dropped down amongst the hot ware, special hollow pillars being made in the setting of the ware directly underneath a series of fireholes in the roof. For each chamber there are sixteen to twenty fireholes, and usually one to three chambers are under direct firing. Only a small quantity of coal is dropped down each firehole, and being in slack form, the volatile matter is rapidly evolved and is burnt in a current of preheated air. All the air for combustion is preheated by coming into contact with the hot goods that have been fired, thus cooling these goods. The gases of combustion then pass forward and preheat the goods before them. There are no intensely cold surfaces near the firing zone, there usually being three to four chambers of goods preheating. Thus, as long as sufficient air is supplied, all the conditions of good combustion and the prevention of smoke are present—small firings of fuel, preheated air and no cold surfaces to arrest combustion. An even more regular supply of fuel may be obtained by the use of automatic coal feeders on top of the kiln.

The emission of much black smoke from the chimney of this type of kiln is a good indication of defective burning, usually of an insufficient number of chambers in the preheating stage. The preheating chambers are then at a lower temperature than they should be. Similarly, smoke is produced if coal is dropped into a chamber before it has obtained a good red heat. A small shovelful of coal down each firehole every 15 minutes gives better results than putting down large amounts at irregular intervals of about an hour or so.

The Hoffman kiln is used mainly for the firing of building bricks. The above remarks also apply to modified Hoffman kilns, including Zig-Zag continuous kilns.

The Belgian Grate-Fired Kiln.

Grate-fired continuous kilns of the Belgian type have, perhaps, the greatest tendency to smoke formation of all the continuous kilns, owing to the method of firing the coal. The kilns are provided with one grate per chamber so that the grates are about 11 ft. apart, whilst usually a long-flame, bituminous coal is used in order to distribute the heat amongst the setting in each chamber. This type of coal easily gives rise to smoke if combustion conditions are not correct. This feature is most noticeable in lighting up a forward fire. In this case the grate, approximately 10 ft. long and 12-15 in. wide, is completely covered with a bituminous coal, i.e. some 2 to 4 cwts., the temperature around the grate being 500° — 600° C when building bricks are being fired.

The firing of this large amount of coal leads to the evolution of a large volume of combustible gases. It is very probable that there will not be sufficient air present to complete this combustion, and also the burning gases will be chilled below their ignition temperature, both due to the large cold charge of coal and to the cold setting in later preheating chambers. With a Hoffman kiln, a chamber can be gradually brought in to the firing zone by gradually bringing in rows of feed holes, besides which only small amounts of coal are added to each feed-hole at a time. With the grate-fired kiln, several shovelfuls of coal are fired on each grate at each baiting, there usually being three

grates under fire. Thus, more coal is fired at a time, and usually at longer intervals than for a top-fired kiln. Hence it may be stated that the Belgian grate-fired kiln often gives smoke emissions during certain periods of the firing operation, especially when the kiln is being forced at a rapid rate, but with care the emissions can usually be reduced. This type of kiln is used for firing common building bricks, facing bricks and firebricks.

The Car Tunnel Kiln.

In the car tunnel kiln, in which trucks of ware pass through a long tunnel chamber which is heated at the centre portion, the fire is always in the same condition, the same rate of combustion being maintained all the time. Under these conditions the fires can be worked efficiently. The secondary air travels down the tunnel being preheated by the goods passing out of the kiln, and this air completes the combustion of the volatile gases in the firing region, the combustion being very rapid in contact with the hot incandescent ware. The hot gases on their way along the tunnel to the stack preheat the goods coming into the kiln. Thus combustion always takes place in the hottest zone of the kiln.

Coal firing on grates and mechanical stoker grates are used, but more often producer gas firing is the method of heating adopted in the heavy clay industry. With gas firing, either of car tunnel kilns or of continuous chamber kilns, firing is under direct control, as the flow of the gas can be easily regulated, and no fluctuations of conditions should occur as with coal firing. However, with gas producers using bituminous coals, tar collects in the gas mains and has to be burned out. This will give rise to dense volumes of smoke during the burning out period, which may last for 1—2 hours per week.

One of the most marked advantages of the car tunnel is that, whether gas or direct coal fired, it is practically smokeless. In general, it produces very satisfactory products and can be made practically automatic in operation. Against this, however, should be set its high cost to build, together with the fact that, in order to fire the kiln efficiently and economically, it should be worked continuously and at full capacity. In the heavy clay industry the car tunnel kiln finds some application in the firing of firebricks, fireclay products and building bricks.

Continuous and Intermittent Kilns compared.

The continuous kiln emits far less smoke than the intermittent kiln, in fact, in many cases, it is practically smokeless. Intermittent kilns are, at the moment, more or less essential in the manufacture of certain products. Further, for small variable outputs in the heavy clay industry, intermittent kilns are much more adaptable to the fluctuating load. Silica bricks are usually fired in intermittent kilns due to the high burning temperature required and to the long duration of the cooling necessary; salt glaze ware is mainly fired in intermittent kilns, owing to the difficulty of salting during continuous operation and to the deleterious effect of the salt vapours on the refractories of the kiln; roofing tiles are practically all fired in intermittent kilns, owing, mainly, to the long and careful water-smoking required at low temperatures; blue and brindled bricks are fired only in intermittent kilns owing to the special reducing atmosphere required.

ADVANCES IN POTTERY FIRING RESULTING IN REDUCTION OF SMOKE EMISSIONS IN THE POTTERIES.

Earthenware and china ware usually undergo three firing operations, namely the biscuit, glaze and decorating or enamel firings. Previously, these operations were practically all carried out in intermittent coal-fired kilns of the familiar bottle-neck type. The biscuit and glaze firings take place in updraught and downdraught ovens, the usual classification being as Updraught, Minton, Wilkinson and Robey ovens, etc.

For the enamel firing, intermittent, coal-fired, muffle kilns are generally used, often two such kilns being built together with the familiar hovel attached. Similarly up to fifteen or twenty years ago, biscuit and glost wall tiles, electrical porcelain and pottery stoneware, were all fired in the same types of intermittent kilns.

There are many indications that improvements and advances in the firing of pottery ware are being effected, and in some modern factories, the old types of intermittent coal-fired oven are being replaced by continuous kilns of the car tunnel design, fired by producer gas, fuel oil or town gas. An advance of this kind carried out some ten years or so ago, was the introduction of the electrically-heated tunnel kiln for firing pottery enamel ware to temperatures of 700° to 900° C. A number of the modern potteries have now adopted the electric tunnel kiln for the firing of decorated enamel ware.

Tunnel kilns have been used for some years for the firing of pottery stoneware, electrical porcelain and glost wall tiles. These kilns are mainly fired by producer gas. Some six or seven such muffle kilns, producer gas fired, are in operation in the Potteries for the firing of glazed wall tiles. For the firing of earthenware and china-ware, in the biscuit or glost condition, there are very few tunnel kilns in operation.

Many tunnel kilns have been installed during the past few years, whilst during the past two years town gas has come into prominence in the Potteries for the firing of tunnel kilns. The use of town gas is a very good proposition if the gas can be obtained at an economic price.

Thus, it would seem that the old coal-fired intermittent ovens used in the biscuit, glost and enamel firings are being superseded by car tunnel kilns, and consequently the smoke nuisance is being abated. It should be stated that about 23 tunnel kilns fired by town gas are now in operation in the Potteries for the firing of wall tiles, electrical porcelain and earthenware. Most of these kilns have been installed during the past few years and they have replaced fifty to sixty intermittent, coal-fired ovens. Other tunnel kilns, town gas fired, are being erected or are under consideration. Taking into account the tunnel kilns fired by other fuels, such as producer gas or fuel oil, etc., the equivalent of about a hundred intermittent ovens have been replaced during the past few years.

Thus, in the pottery industry, progress along the lines indicated above is reducing the amount of smoke emitted during the firing process. At the same time, the economic price of firing the ware is also reduced if fuel and labour costs are jointly considered. With town gas firing, the cost of fuel compared to intermittent oven practice may not be reduced much, although this depends on the price of the gas. The high price of town gas is counterbalanced to a large extent by such factors as constancy of supply, of gas pressure and of calorific value together with ease of control, whilst labour charges are considerably reduced.

But it should be stated that although the above developments are occurring in the larger works, the smaller works, in the main, still rely on the coal-fired intermittent oven.

GENERAL CONCLUSIONS.

(1) With intermittent kilns smoke is produced in some stage of the firing operation, whatever type of product is fired in the kiln. This is due to the intermittent baiting of bituminous coal.

(2) During the first stages of heating, smoke is always produced due to the cold kiln and goods and the large excess of cold air. Conditions resembling those of the domestic fire are prevalent.

(3) For blue bricks, pavers and tiles, where an intense reducing atmosphere is required at the end of the burn, black smoke is purposely made for several hours. This reducing atmosphere is necessary in order to obtain a satisfactory product.

(4) For brindled, flashed or variegated bricks and roofing tiles, alternate oxidising and reducing atmospheres are required in order to obtain the required colour effects.

(5) For salt-glazed pipes an oxidising or slightly oxidising atmosphere is required during the firing. Smoke is more liable to be emitted during the initial stages of firing.

(6) For silica bricks, in order to get the necessary high temperature and to obtain even heating of the goods throughout the kiln, the heat is generated in contact with the goods. Thus the fires are baited heavily and long flame conditions produced. Emissions of smoke are very liable to occur under these conditions.

(7) For firebricks, smoke will be emitted during the initial heating periods and also in the final heating period if high temperatures are required.

(8) In the firing of pottery ware in intermittent kilns, an oxidizing atmosphere is usually required, but due to the large internal volume of the kilns and the necessity of obtaining uniform heating throughout, heavy firings are adopted in order to obtain long flame conditions with the consequence of smoke emissions.

(9) In the case of silica bricks, firebricks, red building bricks, red roofing tiles and salt glaze pipes, the smoke emissions can be reduced, to some extent, by the methods indicated in this paper and by adopting the more modern designs of fireholes. But secondary air, although it reduces the smoke, must be used with care. This air is liable to produce local hot flames, with the consequence, for instance, that uneven and irregularly shaped bricks may result. This localised combustion is prevented by limiting the secondary air and utilising long flame conditions instead, with the greater liability to smoke production.

(10) From the above it is seen that practically all intermittent kilns will emit some smoke during the firing. Continuous car tunnel kilns may be regarded as smokeless; top-fired Hoffman kilns are, more or less, smokeless if fired correctly; grate-fired Belgian kilns are practically smokeless within the meaning of the Act, although they are more liable to emit some smoke owing to the method of firing.

(11) For certain products such as blue bricks and blue roofing tiles, brindled, flashed and variegated bricks and tiles, smoke is produced owing to the reducing atmosphere desired in the kiln. The intermittent kiln is, in many quarters, regarded as the most successful unit for the manufacture of the above products. This is, also, the case with salt-glazed pipes and red roofing tiles, while silica bricks are also, mainly, fired in intermittent kilns. Again, for the small works, the intermittent kilns are used owing to the output not being sufficient to keep a continuous kiln in constant operation.

DISCUSSION.

Mr. E. Harrold (Chief Sanitary Inspector, Oldbury) said that he was more than a little concerned with the smoke problem presented by the brick manufacturing industry particularly as it affected blue brindles and facing bricks. It was accepted that a high temperature of from 1,400 to 1,500 degrees Centigrade was necessary in order to enable the iron silica in the clay to flux and close up the pores, thereby preventing absorption as far as possible and making for a brick of high crushing strain; but was it not possible to attain and maintain this temperature without a reducing atmosphere? We know that it was the carbon monoxide which caused the reduction of the iron compounds and not the smoky fire; therefore was it not possible to obtain the same result (minus the colour) by producer gas or some other known method?

He would also be interested to learn from

Mr. Rowden as to what, in his opinion, caused the blue coloration, the smoke or the fluxing of the iron? If it was mostly due to the smoke then he was convinced that this particular field of industry was standing too much on sentiment.

Dealing with the smoke abatement law Mr. Harrold reviewed some of the methods which had been tried in order to endeavour to comply with the law and described automatic stokers as a great advantage. Electrically heated kilns had made a great advance and oil-fired kilns under most conditions produced good bricks without producing smoke. He mentioned that a few years ago the following remarks were made by a technical expert engaged by the industry at a meeting of manufacturers:—"that the scientific side was fairly well understood but those with the scientific knowledge were being hampered in the application of that knowledge by it being

considered too costly to be regarded as commercially satisfactory, by the owners of brick works."

The speaker concluded by briefly referring to a type of intermittent down-draught kiln which was capable of burning almost every kind of brick, including brindles and facings, without contravening the byelaws.

Councillor C. Ramsell (Nuneaton) said the contents of the paper unfortunately would do nothing to alleviate the problem of smoke emission from brickyards in his area. The first object of any administration was not to place undue restriction and heavy financial burdens on industry and suggested that conversion and co-operation on the question of excessive smoke emission was desirable to abate the nuisance and not to bludgeon industry into submission to one's views.

Dealing with continuous system versus the intermittent one of firing kilns, unfortunately with some regret, he realized that the brickyards in his area were not large enough to permit the continuous system to be used, and this problem was the primary object of his Council sending delegates to the Conference.

He reiterated that it was unfortunate that a comparative table of costs was not given of conversion from intermittent system to the continuous Car Tunnel system.

He was personally interested in this problem because on two sides of the town they had brickyards. They had heard about miners inhaling more grit and dust than any other worker, and this area was predominantly populated by miners, who when at work were choked with dust and when at home were stifled with smoke. It was imperative that they dealt with atmospheric pollution on health grounds immediately.

Mr. C. A. Wood (Chief Sanitary Inspector, Newcastle-u.-Lyme) said the paper was a real practical contribution, proving the difficulties that did exist in that trade. In an area like Newcastle-under-Lyme, which was so dependant on the tile trade, smoke abatement in connection with the intermittent coal-fired kiln was a real problem, so long as retention of the present methods was allowed.

Emphasis was made of the need for further research work more particularly by some independent body who would impartially investigate the conditions from a scientific standpoint. This work could not be reasonably undertaken by individual firms owing to the enormous expenditure necessary in the construction of new experimental kilns which would get away from standard practice.

Instances were quoted where smoke abatement had been successful but where the results from a commercial standpoint had been disappointing. Experience of a local firm's patent kiln which appeared to solve the problem in connection with red and brindled ware was given. It was hoped that this kiln would prove useful even in the blue ware trade.

Mr. James Law (Sheffield, Rotherham and District Committee) said he felt that something should be said about their experiences in Sheffield, Rotherham and District. They had about 24 works in the district with about 60 kilns used for the manufacture of common bricks, fire bricks, silica bricks, refractory goods and sanitary pipes.

The common brick kilns were of the Newcastle, Hoffman and Super Lancashire types, and being continuous kilns there was no great difficulty with regard to smoke. For refractory work, however, there were a number of Beehive type down-draught kilns which had caused trouble and about which the Smoke Abatement Department had had to spend an amount of time and consideration. The difficult period was the *water smoking period*, which lasted for approximately the first three days until the kiln had reached the temperature of about 600° C. When investigating it was found that only a slow increase of temperature was essential and that an oxidizing atmosphere was also necessary. The low-grade fuels being used appeared to be quite unsuitable for this type of firing. Coke was tried and was found to be more suitable as well as less expensive. The use of coke for the early period up to the fourth day had been carried out at certain of the works for the past four years. For finishing, however, it was necessary that coal should be used, but the kiln temperature was then sufficiently high that with reasonable care in firing there should not be any considerable nuisance. There were no exemptions for brick kilns or clay working in his area, and if smoke was emitted in excess of the standard, the matter was reported to the Committee for prosecution if steps were not taken to prevent the nuisance recurring.

Mr. J. W. Beaumont (Halifax), in moving a vote of thanks, said that two very interesting papers had been given in which were set forth the difficulties of the iron and steel and the clay industries, in carrying out their work without creating a smoke nuisance. Although he had no desire to under-estimate those difficulties, he did feel that they were far from being insurmountable, as, indeed, had been said by the authors. The great obstacle put forward was, as usual, the one of expense. It would appear that in regard to exempted industries, those engaged in them were more inclined to rely upon the protection given to them ten years ago than to discover ways and means of carrying on their business smokelessly.

These industries were at present in a flourishing condition and there were definite indications that they would remain so for some time to come. The present was, then, a favourable time to insist that they put their house in order. The time was ripe for considering the determination of exemptions given under the Public Health (Smoke Abatement) Act of 1926. Too little attention had in this respect been given to safeguard the

most vital factor contributing to the welfare of the nation, namely, the public health. They had reached the time when there should be some rationalization of industry in the sense that all small works, where it was not possible to adopt the latest modern methods for the prevention of smoke, must go in the greater national interest.

Mr. Rowden, in reply to Mr. Harrold, stated that for the firing of blue and brindled goods a reducing atmosphere was required. To obtain this atmosphere when using bituminous coal entailed the formation of smoke. There were certain difficulties against the use of producer gas on intermittent kilns in an open brickyard, the chief being that the gas cost nearly twice as much as coal per therm, even when efficiently generated. The blue coloration was mainly produced by the reduction of the red oxide of iron to the black ferrous oxide and the combination of the latter with silica at fairly high temperatures to produce the comparatively fusible black ferrous silicate. Whether the smoke itself affected the colour was an open question. With regard to continuous kilns, many had been and many still were being built in the heavy clay industry, but for certain pro-

ducts such as blue and brindled roofing tiles and bricks and salt glaze pipes intermittent kilns were used owing to the special nature of the firing operation.

Concerning Councillor C. Ramsdell's remarks, he agreed that a spirit of co-operation on the question of excessive smoke emission and the abatement of the same, was desirable between the health authorities and the industry. In reply to Mr. C. A. Wood, he said that, coming from the same district as the latter, he appreciated the difficulties that existed in the trade in the Newcastle-under-Lyme area, and was aware of the efforts being made to abate the smoke emissions and how costly some of these efforts had proved.

He was interested to hear from Mr. J. Law of the use of coke for firing intermittent kilns in the preliminary stages to a temperature of 600° C. The draught on a kiln was often very weak during this initial stage especially during the water-smoking period from 0–200° C. Coke required a good draught for combustion, and he thought that coke fires would be liable to die out during this 0–200° C.

Finally, he expressed his thanks to Mr. J. W. Beaumont for his interesting remarks.

THE SOLUTION OF THE DOMESTIC SMOKE PROBLEM.

By MARGARET FISHENDEN, D.Sc., F.Inst.P.

Chairman: Sir Francis Fremantle, M.D., M.Ch., D.P.H., D.L., M.P,

There is a great deal of truth in the saying that there is "no new thing under the Sun." The smoke nuisance is unquestionably extremely old, for it must have begun almost as soon as Man discovered how to strike a spark, although, at first, when there were no chimneys, the trouble was indoors rather than outdoors. Kipling, in one of his beautiful Just-So Stories, described domestic life long ago, when Man was still "dreadfully wild. He didn't even begin to be tame until he met the Woman, and she told him that she did not like living in his wild ways. She picked out a nice dry cave instead of a heap of wet leaves, to lie down in; and she strewed clean sand on the floor; and she lit a nice fire of wood at the back of the Cave; and she hung a dried wild-horse skin, tail down, across the opening of the Cave; and she said, "Wipe your feet dear, when you come in, and now we'll keep house."

Well, it was wood in those days, and for many hundreds of years afterwards; but now it is mostly coal, which is worse. The great forests of the Middle Ages gradually dwindled as more and more land was brought under cultivation to provide food for an increasing population, and the consequent scarcity and high price of wood encouraged the use of coal, which had been known, and mined, since Saxon times. In the early days it was used only in the arts and manufactures, but, when the industrial age began to set in, the population, and with it our fuel requirements, grew so rapidly that coal gradually became our national fuel, and our great cities earned the unenviable reputation of being the smokiest in the world.

In 1661, John Evelyn appealed to King Charles to pass an Act "enjoyning that all those Works and Fournaces using great quantities of Sea-Coale, the sole and only cause of those prodigious Clouds of Smoake, which so fatally infest the Aer, and would in no City of Europe be permitted, where Men had either respect to Health or Ornament," should "be removed five or six miles distant from London below the River of Thames." As Rose Macaulay remarks in her preface to the reprint of Evelyn's "Fumifugium" published by the National Smoke Abatement Society, in 1933, "we know of better remedies against coal smoke to-day than Evelyn knew, who knew not of anthracite, electricity, coke or gas . . ., but still do the chimneys of London and of the more dreadful cities to her north belch forth noxious and gloomy vapours from their sooty jaws, so that these cities resemble the face rather of Mount Etna, the Court of Vulcan, Stromboli, or the Suburbs of Hell, than an assembly of rational creatures."

After centuries of ineffective effort, we might reasonably infer that the smoke problem is inherently a difficult, or even an insoluble, one; but this is not so. There are no insuperable difficulties in preventing smoke, but, because we need heat in so many different places and for so many different purposes, there are a great many separate small problems to be tackled, rather than any single vast all-embracing one. Smoke is like the fabled bundle of sticks, which could not all be broken at once, but were easy enough to break singly—it needs a persistent and continuous attack, first against one source of smoke, then against another. That is why it is so important that we should each do our share. Perhaps it would help if we could be brought to see the absurdity of some of our present habits, when, in heating our bath water we are as likely as not to cover our neighbours in smuts, or when, after shutting out the sunshine with smoke, we are led by the resulting gloom to poke up our fires.

The Causes of Smoke.

Before we can decide how best to do away with smoke, we must know what causes it, and why some fuels tend to be so much smokier than others. If the housewife understands the production of smoke, she will be in a far stronger position for dealing

with it, whether by a wiser selection of fuels and grates when the occasion arises, or by a more intelligent use of those with which she happens to be provided.

Curiously enough, all common fuels, whether solid, such as coal and coke; liquid, such as petrol and paraffin oil; or gaseous, such as towns' gas and producer gas; have much the same constituents. They all consist essentially of carbon and hydrogen, but may also contain small quantities of ash, sulphur, oxygen, nitrogen, etc. From these, in different proportions, and differently combined, Nature has produced a great variety of substances, just as a clever cook can, from a few simple ingredients, say, butter, eggs, flour and sugar, produce a wide assortment of dishes.

It is the oxidation, or, popularly speaking, the "burning," of the carbon and hydrogen in fuels that produces heat. When carbon and hydrogen are *completely* burned no smoke is produced, and, indeed, nothing but carbon dioxide gas, well known as the bubbles in aerated waters, and water vapour, both of which are colourless, odourless and altogether quite harmless gases. It is only when fuels are incompletely burned that they produce smoke. The conditions for complete combustion sound fairly simple. All that is necessary is that a fuel should be kept above its combustion temperature, which is different for different kinds of fuel, and that it should be brought into contact with enough air to provide oxygen for complete oxidation. With gases, this really is comparatively simple, as they can be mixed with air before arriving at the burners, and consequently can be burned steadily and completely; although, even with gas, an inadequate air supply, or too restricted a space for the flames, or chilling by contact with cold surfaces, may result in the escape of unburned products, including the very poisonous carbon monoxide gas, or even solid carbon particles. For instance, a pan or kettle held too near a luminous gas flame soon becomes coated with soot.

Unfortunately, solid fuel is not anything like so easy as gas either to light, or to burn fully. The molecules comprising, say, a lump of coal, obviously cannot be brought into contact with air all at once. The combustion takes place gradually from the surface inwards, and consequently prolonged heating is necessary to bring a lump of coal to a temperature at which it can go on burning by itself; it cannot be lighted with a match like a gas flame. Moreover, since the molecules of a solid are packed together so densely, it takes an enormously greater volume of air to burn any given volume of coal; and to consume an ordinary grateful, say 10 lbs. of coal, every particle of oxygen in a room 15 feet \times 10 feet \times 9 feet must be brought into contact with it. Fresh air flows in continuously to replace the hot products of combustion rising from a burning fuel, and the draught through the fuel bed is usually increased by providing a vertical flue above it.

If air can get freely at them, small pieces of coal or coke burn more readily than large ones, because they have a bigger surface area in relation to their weight. On the other hand, since small pieces tend to pack more closely together than big ones, it takes a stronger draught to draw air through the spaces between them. Thus, although pulverized coal can be lighted and burned practically as easily as gas in suitable appliances, slack coal, rammed into a grate so that air cannot get through it, is very difficult to burn. With the increased surface of the smaller sizes of fuel tending to help combustion, while the greater resistance to the passage of air through a closely-packed fuel tends to retard combustion, it is obviously of importance to choose the right size for any particular grate or stove.

Bituminous Coals.

In this country, mainly "bituminous" coals are used for domestic purposes. When these coals are heated, they decompose before they become hot enough to ignite, and emit large volumes of combustible gases and tarry vapours. The high proportion of such "volatile matter" in bituminous coals (sometimes over 30 per cent. by weight), makes them easy to light, but unfortunately it also makes them smoky. Under adverse conditions, for instance, just after starting a fire in a cold grate, or for a short time after stoking, some of the tarry distillates, although combustible, may not take fire immediately. Even when they burst into the characteristic yellowish-red flickering

flames to which the charm of the coal fire is often attributed, they may be prematurely chilled by admixture with the cold air entering the flue, or by contact with the relatively cold grate, and in consequence precipitate carbon and tarry particles. These, together with ash and dust, are carried up with the flue gases, and settle on the flue walls as soot, or escape from the chimney as smoke. This incomplete combustion involves a loss of heat. The more smokily a fuel is burned, the less heat will it produce. Thus, smoke puts up our coal bills.

There are a number of solid fuels which contain only a few per cent. of volatile matter, and which, therefore, burn smokelessly, or nearly smokelessly, but which, for the same reason, may be rather difficult to light, and may not burn freely enough to be suitable for use in ordinary open sitting room grates. Chief among these are anthracite and the semi-anthracitic and semi-bituminous coals, and the various cokes, namely, furnace coke, gas coke, and "low temperature" cokes or semi-cokes.

Anthracite.

Anthracite, which is an almost perfect natural fuel, is mined in the South Wales Coalfields; it is nearly free from volatile matter, and has a lower ash content and a higher calorific value than any other solid fuel. Anthracite is dense, hard, and smooth, with a bright black appearance very much like jet, and occupies only about half as much space as the same weight of gas coke. Owing to the custom of washing anthracite and screening it to specified ranges of sizes at the mines, it is free from dust or slack and very clean to handle and store, for it is too hard to get broken up during transport or storage. These points are an attraction to dwellers in flats with limited fuel accommodation, whose supplies must often be taken in at the front door and carried through the hall.

The Welsh and Scotch semi-anthracitic coals with about 10 per cent. of volatiles, and semi-bituminous coals with 13-16 per cent. of volatiles, are another important group of nearly smokeless fuels. They light and burn more easily than true anthracite, the semi-bituminous coals being quite suitable for ordinary open grates, and their calorific value is higher than that of bituminous coals. Their use is likely to extend a great deal for domestic purposes.

Furnace coke is made mainly for metallurgical purposes, by heating coal in closed ovens and so driving off nearly all the volatile matter. Hence, it is very difficult to light, but, as it is always made from washed or cleaned coal, it has a low ash content and is very clean.

Gas Coke.

Gas coke is the carbonized residue left after distilling off all but about 5 per cent or less of the volatiles from bituminous coal at the gasworks. Its properties vary a good deal according to the quality and treatment of the coal used, and the way in which the carbonization is carried out. Generally speaking, coke made in vertical retorts, which have become much more common during the last twenty years, is more porous, more spongy and more bulky than that made in horizontal retorts. Consequently it is easier to burn, especially since the same weight gives a deeper fuel bed. Until recently, gas coke was looked upon merely as a by-product of coke manufacture, and little attention was paid to the desirability of making it a more attractive domestic fuel; the whole of the ash of the coal was left in the coke and, since it was cooled by sprays of water, it often contained high proportions of moisture. Nowadays, however, the crushing, cleaning and blending of coals prior to carbonization, and the dry cooling of the coke, are becoming more and more usual. Certain gasworks also, by slightly limiting the heating of the coal, are leaving in the coke a few per cent additional volatile matter. A number of processes for carbonizing coal at lower temperatures, and thereby producing a far more combustible coke, or semi-coke, containing about 10 per cent. of volatiles, are working steadily, although their combined output is still very small.

The Relative Cost of Fuels.

As a rule, the prices of natural fuels are in rough relation to their quality, although local conditions and demands, costs of mining and transport, and a number of other factors are involved as well. Manufactured fuels are always dearer than the coal from which they are made, partly because of the costs of their production and partly because there is always some heat used and some heat lost in the process. Of all the forms of energy into which the potential heat of raw coal can be converted, electricity is the most convenient, because it is so clean, so adaptable, and so easy to control; but unfortunately there is a much more serious loss of heat in making electricity from coal than in carbonizing it. Roughly speaking, taking all our generating stations together, the electricity made is the thermal equivalent of only 15 per cent of the coal; for the most efficient stations it is 25 per cent. A better quality of coal has to be used for making towns' gas, but 25 per cent of its heat goes into the gas, and 50 per cent into the coke. Consequently, while heat bought in electricity at, say, 1d. a unit costs fifteen times as much as heat bought in good quality house coal at 50/- a ton, heat bought in gas at 10d. a therm costs only five times as much.

In some places electricity is offered at special terms, perhaps during certain specified hours; in other, a sliding scale gives preference to the large consumer. Moreover, the prices of fuels fluctuate and vary from place to place. This makes it hard to decide on fair average prices to take for comparisons, but the following values are reasonable, and can easily be modified :—

Fuel	Price	Calorific value	Price Relative to that of Coal
House Coal	50/- ton	13,500 B.Th.U. per lb.	1·0
Gas Coke	40/- ton	12,500 B.Th.U. per lb.	0·9
Semi-anthracite or semi-bituminous Coal	55/- ton	14,500 B.Th.U. per lb.	1·0
Anthracite	72/6 ton	14,750 B.Th.U. per lb.	1·4
Semi-coke	60/- ton	12,750 B.Th.U. per lb.	1·6
Town's Gas	10d. therm		5
Electricity	½d. unit		7
Electricity	1d. unit		15

The above figures do not indicate the actual costs of the different fuels to the housewife, for electricity can be used much more efficiently than any fuel, and gas can be used more efficiently than any solid fuel. Hence, for any purpose, less heat is needed in electricity than in gas, less heat in gas than in solid fuel. Whether this can make up for the initial discrepancy in prices depends upon the circumstances—sometimes it can, more often it cannot.

The Uses of Fuels.

The prevention of smoke lies essentially in using the right fuel for the right purpose, and although in some cases this might mean a slightly increased cost, the present unsatisfactory state of affairs is largely due to imperfect organization. The housewife does not always know what types of fuel are best for her particular purposes and, in any case, cannot be sure of getting uniform supplies from her coal merchant. If the country's fuel supplies were properly classified and distributed, and the coal merchant could be relied upon to advise the housewife as to the best types of fuel for different purposes, a great step forward would have been taken.

The domestic problem is complicated by the fact that in all households, whether rich or poor, heat is needed for keeping the rooms comfortable, for warming water, and for cooking food, as well as for a number of other minor purposes. Moreover, the scale of the requirements, and their relative importance, varies widely from one establishment to another. The appliances used may be divided broadly into the following classes :—

Open Fires (solid fuel or gas, including incandescent electric heaters).

Ranges with Ovens, with or without Boiler (solid fuel, gas or electricity).

Independent Boilers (solid fuel, gas or electricity).

Central Heating Installations (generally solid fuel or oil).

Slow Combustion Stoves are not considered as they nearly always burn smokeless fuel.

Open Fires.

For continuous use, solid fuel is much cheaper than other for open fires. The semi-bituminous Welsh or Scotch coals, which are nearly smokeless, are quite suitable, and cost no more than bituminous coal. Alternatively, semi-coke or a mixture of anthracite and semi-coke, can be used quite smokelessly and with great flexibility, although not quite so cheaply. In grates of ordinary design, anthracite or gas coke is usually too hard to light, and does not burn freely enough; for this reason a number of grates of special design have recently been put on the market, and some of these are very successful, either with gas coke or anthracite. Ash collecting over the bright fuel, and so spoiling its appearance and cutting off some of the heat, is the chief defect of coke fires; further, they tend to go out if the rate of combustion is too far reduced, or the fire allowed to get low. Where a gas firelighter is fitted for lighting and resuscitating fires, a low ash content is of more importance in the fuel than a low ignition point or high combustibility. The cost of turning on the gas for an occasional half-hour is not serious and, with its help, anthracite or oven coke, both of which are very clean, can be used.

The latest type of gas fires are very attractive. They are bright, efficient, and silent, and give no trouble. For the same heat consumption, they give about twice as much radiation into a room as solid fuel; this, of course, helps to make up for the high price of gas, but for continuous use it is still more than twice as dear as coal or coke, and nearly twice as dear as anthracite or semi-coke. For intermittent use the position is very different, and if a room is used for a total of less than three or four hours a day, made up of several shorter periods, gas will be actually cheaper than solid fuel.

The difference in price between electricity at 1d. a unit, and solid fuels, is still more marked, and, although there is no loss of heat with flueless electric "fires," and their portability sometimes reduces the heat requirements, they cost three or four times as much as solid fuel for continuous use. For an odd hour or two a day, they are convenient and may be economical. At ½d. a unit, electric fires are cheaper than gas fires.

Ranges with Ovens.

If a range is lighted and kept going solely for cooking purposes, it costs just as much as a gas or electric cooker. On the other hand, for winter use in a small household, a modern kitchen range will cook, heat the tap water and warm the kitchen more cheaply than can be done in any other way, except, perhaps, by a small open fire with back boiler, and a small gas cooker. In larger households, it will pay better and be more convenient to have an independent boiler for hot water supply, possibly with a pipe running around the kitchen to give it extra heat in winter, and a gas or electric cooker. Alternately, a fairly large closed kitchener, and a small gas cooker for occasional use may be convenient. Very low volatile fuels are not suitable for top-heated ovens, and back boilers also are easier to manage with a flaming fuel; in such cases, semi-bituminous coal should be used. This can be obtained in washed and sized grades, from cobbles to bean size, under branded names. Anthracite or gas coke can be burned in specially designed ranges, and in some ordinary ranges.

Independent Boilers.

Where large quantities of hot water are wanted nothing can compare with independent boilers burning some type of coke or anthracite. They are cheap, clean, efficient and convenient, and are quite neat in appearance. The larger sizes can be connected to one or two radiators, and some designs include an oven. Many can be

used with a small open fire in cold weather, and work well in conjunction with a gas cooker. For a given hot water production, the running cost is only half to a quarter that of a back boiler, or half to one-third that of gas or electricity. There is, however, in the smallest sizes of boiler, some difficulty in keeping alight a very slow fire of gas coke, say overnight. If the draught is reduced too much, the fire tends to go out, leaving a considerable quantity of coke still unburned; on the other hand, if a free draught is left, too much hot water may be produced, and the fire need attention at frequent intervals to prevent its burning through. The combustion of anthracite or semi-coke is easier to control, and consequently, especially if the cylinder is insulated, a smaller quantity may suffice, and the higher initial prices be compensated for. Alternatively, a mixture of coke and semi-coke can be used.

There is no point in installing an independent boiler where the demand for hot water is small and intermittent. In such cases, an open grate with back boiler in the kitchen, burning coke, semi-coke, or semi-bituminous coal, or a small gas circulator would be more economical. Alternatively, at $\frac{1}{2}$ d. a unit, or less, electricity would be quite feasible, and cost only about as much as gas.

Central Heating Installations.

In the comparatively large furnaces of central heating boilers, a smokeless fuel such as coke or semi-bituminous coal should always be used, and is quite suitable. Alternatively, especially when putting in new plant, the possibilities of oil should be looked into. At 95/- a ton, it would cost 25 or 30 per cent more than solid fuel, but, since it can be regulated automatically, and cut off immediately the house becomes too warm, less heat is used.

Conclusion.

Smoke abatement enthusiasts often assert that coal grates should be abolished by law, but this would not be feasible except over a long period of years. Forty million tons of raw coal are burned annually in our domestic grates, far more than the 25 to 30 tons treated by gasworks and electricity stations together. To replace this domestic coal by gas and coke the existing gasworks capacity would have to be trebled—not a thing that could be done in a year or two. The extended use of gas, coke and electricity should be given every reasonable encouragement, but in the meantime something must be done to reduce the smoke emission from coal grates. The kitchen range is probably the worst offender, although fortunately a rapid increase in the use of independent boilers and gas cookers is taking place. Large quantities of bituminous coal are also burned in open grates of the sitting-room type. This is not necessary. Among the natural smokeless fuels, namely, anthracite and the semi-anthracitic and semi-bituminous coals on the one hand, and the manufactured smokeless fuels, gas coke, oven coke and the semi-cokes on the other hand, a smokeless substitute can always be found at little extra cost, and sometimes actually at a lower cost. But the necessary re-distribution of fuel supplies will probably take some time.

Even where bituminous coal is used, the smoke emission can be cut down a good deal, although it cannot be altogether prevented. Cinders saved from a previous day's fire are excellent for lighting purposes, and do away with the usual heavy smoke emission at this stage. If they are built up lightly above the wood or firelighter in the grate (care being taken that air can easily get through the spaces in the firegrate), and both the dampers in the flue and the air inlet below the fire opened, the fuel will kindle quickly, and pans or kettles put on it will not get covered in soot. When the fire is well alight, coal may be put on, and should light almost at once, especially if it has been kept in a warm place. Subsequently the dampers can be adjusted as required. Kitchen ranges should be stoked when oven or water heating is wanted, partly because, with open flues, the coal will light quickly, and partly because flame is very effective for heating the oven or boiler. In any case, the draught should be opened up for a few minutes after stoking, or until the coal is flaming freely; otherwise it may smoulder, and

give off a lot of smoke. Fires should not be damped down with slack; the right way to keep a slow fire is to shut the dampers and air inlets after most of the flame has burned away, or, better still, add a little coke. If proper draught control is available, slow burning and comparatively smokeless fires can be kept up without attention for a number of hours. The ash which accumulates on the firebed acts as a seal and prevents air getting through. To rouse the fire, it is only necessary to poke away the ash, open the air inlets, and wait a short time for the cinders to glow before adding more coal.

It is useful to remember that the canopy adjustment of sitting-room grates controls the air drawn into the flue, or the ventilation of the room; while the air-inlet below the fire controls the rate of burning. Thus, if a rapidly burning fire is wanted, it is imperative that air should be able to enter the fire freely from below; if a high rate of ventilation is wanted, the canopy, or flue damper, should be opened wide.

To prevent smoke, a united effort on the part of all the housewives of the country is wanted; with their help, backed up by the fuel producers and fuel merchants, the smoke nuisance would be almost non-existent ten years hence.

DISCUSSION.

Mr. W. C. Goodchild said that the title of this paper would have raised the hopes of many that the problem of burning bituminous coal in domestic grates, with a minimum of smoke, had at last been solved. On reading the paper, however, one was disappointed that, instead, the solution proposed by the author was really an evasion, i.e., to use anthracite or semi-bituminous coal, coke, gas or electricity. No attempt was made to apply the principles of combustion to the design of suitable grates for bituminous coal.

It was of little avail to tell the harassed housewife that "When carbon and hydrogen are completely burned no smoke is formed"; or that "If she understands the production of smoke she will be in a far stronger position to deal with it," unless she is also informed how to acquire this knowledge. He could imagine in some cases the reply would be more forcible than polite. They must remember that the majority of housewives were only tenants and therefore not in a position to make "a wiser selection of grates": and as for the selection of the best fuel for any purpose, the housewife would consult her neighbours rather than the coal merchant, and probably with more success.

Some years ago, before the Institute of Fuel, he gave the results of some tests on boilers which had been made for the purpose of raising the boiler efficiency and reducing smoke. Emphasis was given to the necessity for the existence of three factors when burning bituminous coal. They were called the three T's and are "Time, Temperature and Turbulence." "Time" implied an adequate volume of combustion chamber. "Temperature" was governed by the nature of the combustion chamber wall, the excess of air through the grate, and the volume and temperature of the secondary air. "Turbulence" was necessary to mix adequately the com-

combustible gases with the preheated secondary air, otherwise the mixture could not unite in a chemical combination.

How did we find these principles applied to the domestic grate? The combustion chamber in the parlour type of grate was an open space between the top of the fuel bed and the mouth of the flue, which was swept by a stream of cold air from the room, the air and combustible gases flowing in parallel stream-line paths and not mixing. Thus each of the three T's was violated.

It was not possible to design a grate, or even to adapt existing ones, incorporating the three factors for good combustion with bituminous coal. Knowing what research had done he was bold enough to take an optimistic view of the future for this coal in the domestic grate.

The problem could be considered under three headings:—

1. The author had given the quantity of bituminous coal used for domestic purposes, and any suggestion to use anthracite and semi-bituminous coals as a substitute, should be considered in relation to its effect on employment in mining areas. What would the inhabitants of the Midlands, Lancashire and Yorkshire, for example, say if told to buy anthracite from S. Wales or Scotland? After all, availability and price were, and would remain, the dominating factors in the housewife's choice of coal. It was up to the technician to provide a grate in which any class of coal could be used satisfactorily. The human element was an important factor in "operation" and unfortunately the average housewife was not able to benefit by any technical explanations. For example, what would be her attitude to this advice: "The conditions for complete combustion *sound* fairly simple. All that is necessary is that a fuel should be kept above its combustion temperature, and

brought into contact with enough air to provide oxygen for complete combustion." How frequently was fresh coal spread all over the red embers, whereas if the latter were first drawn forward and the fresh fuel placed at the back, some brightness was retained and the distilling gases more quickly ignited.

The fact that the smoke nuisance from domestic chimneys, allowing for the increased population, was no better now than it was 50 years ago, was surely an indication that the housewife had not yet understood the production of smoke, and for the obvious reason that she had not been taught.

They had, however, in the present-day girls of school age the housewives of the next generation, and it was suggested that instruction should be given to them, through the medium of the chemistry, physics or domestic science classes, on the elementary principles of combustion, in particular relation to the use of bituminous coal in the domestic grate. They could then apply the acquired knowledge at home, to the benefit of the public health, and possibly their parents' purses.

2. In his opinion many builders and manufacturers of grates were as much in need of guidance as the housewife. How frequently did they see the technical side subordinated to the ornamental, or, as some would say, the artistic? In such cases probably 90% of the cost of a fireplace was for faience, and only 10% for the important part, i.e., the grate.

About six years ago, when he was resident in a midland town, he took an early morning walk one Sunday and observed from a large recreation ground that the chimneys of the houses on one side were creating a pall of bluish smoke, while on the other side they were practically smokeless. The former houses had only been built about two years, whereas the latter were at least 32 years old. He could only conclude that the modern grates gave less efficient combustion. This was not surprising when many so-called "slow-combustion" grates were only distilling the coal, instead of providing high temperature combustion. In recent years the gas fire had been greatly improved through the enlightened policy of joint research, which had been undertaken for manufacturers of such heating appliances. If similar attention was given to the improvement of the coal fire the smoke evil would be soon mitigated. It was therefore suggested that the Society should collaborate with the Coal Utilisation Council, the Fuel Research Board, and grate manufacturers for research on the evolution of grates to be used with bituminous coal.

3. The valuable work done by the Fuel Research branch of the Department of Scientific and Industrial Research, by evolving a method of accurately measuring the density and quantity of solids in smoke from the domestic chimney, should enable reliable comparisons of all types of coal-consuming domestic grates to be made, and it should be

possible to fix a standard of "smokelessness" which could be reasonably attained.

Was it too much then to expect that legislation should be introduced empowering local authorities, when passing the building plans, to prohibit the installation of grates in new dwelling houses unless the pattern has been tested and approved by the Fuel Research Board?

When a method of modifying existing grates at a reasonable cost had been evolved, its installation should also be compulsory before the expiration of a period of years.

Mr. Bennett (Director of the Combustion Appliance Makers' Association) said that he represented the team of workers who were trying, by means of research, to evolve appliances which would burn coal smokelessly for domestic purposes. Whatever might be one's belief in the future of gas and electricity—and he believed that they would go from strength to strength—the fact remained that many millions of coal fires were installed in this country, and continued to be installed every year. The vast majority of these burned bituminous coal, and they were all, to a greater or lesser degree, producers of smoke.

There was, therefore, an immediate practical problem of reducing the smoke from domestic fires burning bituminous coal. What had been done in power stations and the large coal-burning installations could be done on a small scale. It had been fully established that smoke, if ignited at the moment it was produced from the coal could be consumed virtually without trace. In lighting a coal fire it was necessary to have a flame hot enough to set fire to the volatiles emitted from the coal at the very moment that they left the coal surface. It was also necessary to have enough air to ensure complete combustion.

The Research Department of the Combustion Appliance Makers' Association (Solid Fuel) had been engaged on this problem for some time, and, with the co-operation of the Gas Light and Coke Company had evolved a gas-igniting device which appeared to have solved the problem. Instead of the usual gas poker, or gas jets at the bottom of the fire, a jet was directed downwards under pressure so as to play over the top surface of the coal in the grate. This meant that the smoke leaving the coal had to pass through a zone of flame by which it was consumed. A further effect of the jet was to create a turbulent current of air, through the bed of coal, thus ensuring that it did not smoke from "oxygen starvation." A special feature of the device was that it had been combined with automatic ignition, so that, in future, it would be possible to light fires simply by turning on a tap, without the use of matches, paper or wood. His Association had always felt what was emphasized by Dr. Des Voeux in his Presidential Address, namely that the housewife was more interested in her imme-

diate convenience than in the smoke which might go out of her chimney. They had, therefore, taken pains to combine smoke abatement with labour saving and cleanliness, and hoped, in this way, to encourage the use of these smoke abatement devices wherever coal fires are in use. He felt that in this way they would have done something immediate and concrete to reduce the smoke from domestic chimneys and earned the commendation of the National Smoke Abatement Society.

Mr. W. R. Gordon (Coal Utilisation Council) said that Dr. Fishenden had read, as was only to be expected, an excellent paper, moderate and statesmanlike in its outlook. It was clear from what Dr. Fishenden had said that substitutes for coal were not available in sufficient quantities in this country at the present time, and that in any event their price was too high for the bulk of consumers, especially the poorer ones.

The solution of the problem of smoke abatement in the domestic sphere should not be to abolish the use of coal but rather to show how it could be used smokelessly. The Joint Research Council, set up by the Combustion Appliance Makers' Association and the Coal Utilisation Council, had recently invented a new device for igniting coal fires with gas. This device was not like the ordinary gas poker but was arranged so as to light the fire from the top. Not only did it make the lighting of coal fires easy and automatic but it prevented the emission of smoke when starting a fire in a cold grate. This principle, Mr. Gordon understood, was one that Dr. Des Voeux himself employed when lighting his own coal fires, namely that he lit them from the top.

In conjunction with the Fuel Research Board, the Coal Utilisation Council had reached the stage when it was possible to measure the emission of smoke in open grates. This step having been completed it was now possible to make tests of various grates and devices, about fifteen in number, which had been submitted in the hope that they might solve the problem. Some of them, coupled with this gas ignition device, might be said to have brought within sight a solution to the domestic smoke problem. Mr. Gordon hoped that the Society would welcome this development and when it had been brought to completion cease to vilify the use of coal in the open fire.

He was sorry on one point to have to differ with Dr. Fishenden. Bituminous coal could be very satisfactorily used with automatic stokers quite smokelessly. This was due to the underfeed principle employed. Oil was in this country, at the present time, largely out of court, on the score of expense, so far as central heating was concerned. Thermostatic control could be applied to coal burning appliances quite as easily as to those using oil. Anyone who was interested in this matter

could see for themselves how this had been successfully done by visiting the demonstration centres maintained by the Coal Utilisation Council both at the Building Centre and at British Industries House.

Dr. Fishenden had criticized coal merchants and suggested that they should act as advisers to their customers. The coal industry was fully alive to the need for these advisory services and, in fact, the Coal Utilisation Council had brought into being a course of training for coal salesmen which had been widely taken up throughout the trade.

In conclusion, Mr. Gordon invited the Society to seek co-operation with the coal industry rather than adopt a policy which might appear to outside observers as pushing the sale of other classes of fuel than coal.

Dr. F. M. H. Taylor, Ph.D. (Gas Light and Coke Company) said he was sure it was agreed by all that the presentation of the methods of combating the domestic smoke problem could not be entrusted to more capable hands than those of Dr. Margaret Fishenden. Her work on the subject over the past ten to fifteen years had been accepted as fundamentally sound as well as providing a really scientific approach to the subject, which had been fraught with a number of difficulties—lack of data, lack of accurate means of measurement, lack of ability to forecast the taste of requirements and prejudices of the public.

Assuming, however, that they agreed substantially with the methods that Dr. Fishenden had indicated for combating the domestic smoke nuisance, he felt that interest might be transferred to the practical means of bringing about these reforms.

He had the honour to be associated with a gas undertaking that had spent considerable sums of money on research and investigation into the methods of providing adequate and inexpensive heat and hot water supplies to the very poorest classes of the community by means which avoided this evil of atmospheric pollution.

Dr. Fishenden's prices of fuels were substantially correct, but the Conference must face the position which would be created if the 40 million tons of domestic coal were suddenly replaced by either anthracite, electricity, gas or coke. The cost of anthracite had already risen by 3/- to 4/- per ton consequent on an increase in sales of barely 500,000 tons per annum, and besides it was quite easy to imagine the effect on the supply to the poor consumer on a further extension of its field of use. The cost of electricity for space heating depends largely on load factor. The small amount used for fires could be provided at present at approximately $\frac{1}{2}$ d. per unit because no standing charge is made. For this supply to be economic once it had become a really important load, a standing charge of £5 per kilowatt would have to be made, so that the cost of running the average 2 k.w.,

electric fire would rise from 30/- per annum to £11 10s. per annum.

The supplies of gas, however, could be increased indefinitely with, if anything, a reduction in cost of manufacture, and an indication of this is a recent step made by his own Company in providing gas under a two-part tariff scheme at 4d. per therm, which was approximately equivalent to electricity at 4d. per unit.

Further justification for the replacement of the smoky coal range by smokeless fuels must obviously come from the policy of the big public housing authorities. Data taken from a number of tenement flats was summarised:—

The coal range consumption taken from "The New Survey of London Life and Labour" showed that 1½ cwts. of coal were used per week on an average, which assuming a price of 2/6 costs 3/1 per week, to which must be added an extra 6d. for the amount of gas or electricity used for kettle boiling and the occasional use of the gas cooker or wash copper. If this was replaced by smokeless fuels, a survey of Sassoon House, Peckham, and Basil House, E.1., had shown an average of 2/9 per week for cooking and water heating (15 gallons per day) to which must be added coke for the living room grate 2/- per week, making a total of 4/9 as against 3/7.

In comparing these figures it must be remembered that should the standard of living, which was after all improving year by year, of the older-fashioned tenements costing 3/7 per week, be raised to that of Sassoon House, for example, an additional amount of hot water used would quite easily bring the total cost up to 4/9—or looked at another way, social workers and housing authorities were agreed that this was the minimum standard at which they should allow their fellow creatures to live, and that the use of gas for crater-heaters and cookers was recognised at least as cheap as any other means by which this could be provided.

Although large central plants for provision of central heating and hot water to tenement schemes had been considered, estates such as the Ossulston Street Estate of the L.C.C. as well as one or two in Liverpool and Manchester had proved that although smokeless combustion may be achieved by the use of special coal or coke-burning appliances, the capital cost as well as the losses through long pipe runs was so prohibitive that the project was out of the question for economic reasons.

Mr. R. Clayton (Coal Utilisation Council) said that in her brief reference to current central heating practice it was surprising to note that Dr. Fishenden made no reference to the use of ordinary bituminous coal for that service, and there was complete absence of reference to the automatic underfeed coal stoker, of which there were no less than about a dozen different makes to choose from. The practice of underfeeding the fresh coal was

probably the most scientifically correct method that had yet been devised. The great success of this type of stoker arose from the fact that the volatiles, together with the air of combustion, were compelled to pass through the incandescent bed of fuel. In so doing they were thoroughly mixed, heated to a high temperature and were burned without the production of any smoke whatsoever. Moreover, the thermal efficiency of that type of solid fuel burning appliance excels, as an ever-incandescent surface was presented to the boiler, allowing of the major portion of the heat in the fuel being absorbed by radiation.

It was true that this method of firing involved mechanically feeding the coal into the furnace, but the design of the automatic underfeed coal stokers had been highly developed and the device was thoroughly reliable in practice when supplied with non-caking bituminous coal of suitable size. Moreover, with this device fuel costs per unit of heat generated were frequently a minimum, and fluctuating loads would be very readily met. It was therefore, incorrect to-day to suggest that oil should necessarily be considered as an alternative fuel for central heating installations.

Bailie A. Munro (Glasgow) thanked Dr. Fishenden for her paper. He was of the opinion that smoke could be entirely prevented in industrial furnaces. The easiest method of abolishing smoke in the home, he considered, was the electrical.

Mr. E. K. Regan (Powell Duffryn Associated Collieries Ltd.) said (in a contribution read by Mr. Paul Tingey) that Dr. Fishenden was to be congratulated on her paper inasmuch as it was evident that she appreciated there were coals in South Wales apart from anthracite, which could be efficiently used for domestic purposes, particularly with regard to smoke abatement. It was regretted, however, that in the paper, Welsh and other coals of the 10 to 16% volatile range were not considered worthy of a separate heading, it being noted on pages 26 and 27 that the captions referred to bituminous coals, anthracite and gas coke. The useful domestic sphere of Welsh coals with a volatile range of 11 to 14% had not been fully appreciated in the past. At the present time, however, the demand was rapidly increasing, a fact which should appeal to any movement devoted to smoke abatement. These fuels were practically smokeless under all domestic conditions, and, in addition, they had a sulphur content as low, and if anything, lower than any solid fuel, which again was a factor of importance on the question of atmospheric pollution. Such coals were used in increasing quantities for small hot water boilers, heating stoves, sectional central heating boilers, etc., and, in addition, they were perfectly applicable for use in any open fire which had a refractory backing.

Dr. Fishenden would, of course, appreciate that the afore-mentioned grades of Welsh coal were prepared and marketed as a washed and sized product in specified ranges of sizes. The statement on page 27 under the heading of anthracite, with reference to the custom of washing and screening for domestic purposes, would almost imply that washing and screening was peculiar to anthracite only.

With regard to central heating installations, Dr. Fishenden very clearly indicated that oil fuel at present prices was almost prohibitive on the grounds of cost, but credited this fuel with the advantage that it could be regulated automatically so as to keep a room or house at a constant temperature. Dr. Fishenden would, no doubt, appreciate that this convenience was not peculiar to oil firing, as there were on the market quite a number of makes of thermostatically controlled coal burners, both of the gravity feed and under-feed type which would give equal temperature regulation with all the convenience usually associated with oil firing. The use of such appliances was very rapidly extending and must constitute a considerable contribution towards smoke abatement. Here again, although these machines were not primarily designed or considered suitable for Welsh coal other than anthracite, suitable grades of Welsh dry steam and semi-bituminous coals had been found to fulfil the most exacting requirements of these machines and they had most definitely established that, although combustion under such modern methods was, on the whole, smokeless, absolute immunity from smoking could be claimed when these fuels are used.

Mr. Paul R. L. Tingey (Powell Duffryn Associated Collieries Ltd.) said that there was one matter which he considered required emphasizing arising out of Dr. Fishenden's paper and that was the statement which appeared under the heading, "Independent Boilers," namely:—

"Where large quantities of hot water were wanted, nothing could compare with independent boilers burning some type of coke or anthracite."

It would, no doubt, be of general interest to know that, at the present time, at least 80% of the Welsh natural smokeless coals for domestic purposes were consumed in

independent boilers where only coke or anthracite were advocated.

As regards supplies of Welsh smokeless coals, which, of course, include anthracite, it would be no exaggeration to state that there were sufficient proven deposits to supply, if required, *the whole of the domestic requirements of Great Britain*, computed to be 40 million tons per annum, for several centuries, estimated by some authorities at 600 years.

Mr. E. H. Keeling, M.P. (Westminster City Council), said that Westminster was installing in its new workmen's flats on a fairly large scale grates with a gas point, which would burn either coke or coal at the tenant's option. What progress could be expected in overcoming the objections to burning coke? Had the all-coke experiment made on a new housing estate in Lancashire been successful?

Mr. John Roberts pointed out that Welsh natural smokeless coals were within the reach of one-third of the population of Great Britain. These coals can be used successfully in open grates, domestic boilers and closed stoves.

Councillor C. Ramsell (Nuneaton) congratulated Dr. Fishenden on her paper for the practical way in which she had dealt with her subject. He proceeded to deal with the question of relative cost of fuels, and suggested the housewife bought the cheapest qualities of coal owing to economic reasons.

He agreed with the question of coal merchants advising housewives on qualities of coal and not with selling coal simply as "black stuff," and supported Councillor Munro, of Glasgow, who said the problem of smoke abatement would resolve itself into smoke abolition if electrical appliances and power were able to compete cheaply with coal and come within the reach of all persons of the community.

One of the problems was to convince the miner who as in receipt of free coal to abate the smoke nuisance when remedies suggested by Dr. Fishenden were more than he could afford. He contended one of the problems for the Society to face frankly up to the practical, and suggested that if coal was to be the predominant fuel than some standard of quality should be enforced.

THROUGH A GLASS DARKLY.

By NOEL CARRINGTON.

In a recent series of broadcast talks Professor Ritchie of Aberdeen was showing us that the one essential vitalizing force in the whole of our universe—in plant, insect, animal and human life—is nothing else than the sun. It is the sun which makes it possible for the plants to turn the air and water into starch, on which insects and animals feed. In eating either animal or vegetable food we are simply drawing for our energy on the forces stored up by other forms of life. But we in our turn need sunshine for our own natural development, and that is precisely what we have deprived ourselves of, not consciously, but insidiously in the cumulative process of modern civilization.

It is necessary to emphasize how gradual and insidious this loss of sunshine has been, because how else can we explain the apparent suicidal tendency in mankind to deprive himself of Nature's great energizer. But just as through some faulty habit in diet the human system is poisoned bit by bit until vitality is lowered and the victim no longer remembers what it is to be in health and hardly cares whether he is or not, so society in its city life takes it for granted that sunshine shall rarely break through the vast canopy of gloom, and women battle without hope against the all-pervading smuts. With the first advent of coal as fuel in our cities, the nuisance was felt to be intolerable. Elizabeth, James I and other monarchs issued law after law to forbid the use of coal. Evelyn complained bitterly of the damage the smoke did to gardens and was inspired to advocate for the first time a green belt around London to mitigate the evil. I need not say that all our legislation was abortive and that the air of 17th century London was no doubt a paradise of sweetness compared to our own. The Englishman grew accustomed to smuts and fogs. He even came to be rather proud of it. It showed what stuff we were made of that we could breathe such air and yet rule half the world.

Compensations.

The result on our national life has been that we have sought not to end it by rational means, but to find a number of compensations. Some of these are harmless enough if generally ineffective. Medical science has had to devote much research to diets which will compensate for deficiency of sun, and the business men who blot out the sun with their factory smoke were not slow to grasp the possibilities. Vitamin content is one of the first selling points for branded food and drink products in current advertising. Artificial sun-ray treatment has been found to act as a substitute for at least some of the sun's gifts. But there is something a trifle ridiculous in our solemnly taking as medicine what was once man's natural heritage. Even more pronounced is the passionate pursuit of sunshine on brief holidays and weekends, the ritual exposure and bronzing for days or weeks at a time, a movement which has brought into being the whole industry of roadhouses, swimming pools, seaside resorts and cruising. Some of this no doubt is due to the intolerable noise and speed of contemporary life and would not be much diminished if our skies were clean, but we must certainly allow the craving for sunlight and, what is no less important, for uncontaminated air to breathe as a major impulse.

The unhealthiness of our cities is not in effect a thing which most of us reason about at all. We simply become subject to a restless feeling that something is wrong and that we want to get away. The same feeling that wild animals must suffer in their wretched zoos or wild birds in their cages. Some who are born in cities and have never known the country are not aware of any such impulse. The Victorians, who had smaller facilities for travel, accustomed themselves by necessity to their urban conditions. Nowadays we all go outside our cities from time to time, and our senses therefore are bound to feel the differences of air.

At first it was only the richer classes of the community which could afford to own their weekend retreats or take weekend expeditions, but within recent years motor

transport has made travel so easy and cheap for all but the very poorest that the exodus from the cities is on a national scale. The same basic impulse drives nearly all who can to move their homes from the cities to dormitory suburbs or smaller towns where the air seems comparatively pure, pure enough at any rate for a little sun to penetrate and for garden flowers to bloom. Each new estate is advertised as being in unspoilt countryside (reflecting the prevalent idea that to build is to spoil), but within a few years this same estate is miles away from any countryside, and very soon is engulfed in a new smoke belt of its own.

In recent years this outward spread of towns has alarmed us (as it did Elizabeth for other reasons) and all but the most insensitive deplore the shrinkage of the old agricultural scene. The typical modern landscape is neither urban nor rural; it is a hybrid which is by no means beautiful. The outcry is loudest among the rich (who had already staked out their claims in discreet country houses and cottages sufficiently far apart not to offend each other's views), but the pursuit of the unspoilt view is only accelerated, for the fundamental urge to escape is still here with us in our cities, and no restrictive Planning Acts can restrain it effectively.

The Decay of Civic Spirit.

Concurrently and inevitably this centrifugal tendency has been matched by the rapid decay of civic spirit. The wealthier classes for the most part no longer inhabit the cities in which they work, and take no part in their government. The so called "City man" knows little and cares less about the city of London. Nor does the county in which he lives count for more. He is a nomad. His only interest in his place of work is how easily he can get away from it. It is little wonder, therefore, that our cities have no plan, no coherent architecture, and few public buildings worth the name. The appearance of the great streets responds to the use to which they are put. They become sites for advertising, either by pretentious facades or by illuminated signs. The governance of cities is left largely to the shopkeepers and the professional staff.

I have said before that this disintegration of civilization is not wholly due to the pollution of air and that other nuisances are also to be held responsible, but I doubt if any single influence is comparable with the natural impulse to get away from the gloom and dirt of city life. The remedy will not be found in making still easier the escape to suburb and countryside, because except for the richer classes, the escape soon becomes an illusion. Moreover, there are many, if not a majority, who must live close to their work and whose children are therefore condemned to the bad conditions. The remedy is obviously to clear the air of smoke and thus render city life again healthy and tolerable. We know that technically it is now perfectly feasible. We know that economically it would be profitable to the community. All those facts have been demonstrated by your Society for many years. They are quite indisputable. What is necessary is to so marshal public opinion that the opposition of private interests and the lethargy of the official world is overcome.

Let me quote a recent case I read in my local paper. The competent official wrote to the Managing Director of a Paper Mill to complain that the smoke from his mill chimneys was polluting the air of the whole district. The nuisance, I know, is obvious and notorious. The director wrote back in a highly indignant strain to say that his firm had made improvements and now considered the smoke negligible. The local Council read the correspondence, debated the matter, agreed the smoke was to all appearances as bad as ever, tabled a resolution to publish the correspondence, and there the matter was left. In short the firm got away with it. Incidentally it pays its shareholders a very handsome profit. Naturally, business men do not like to see profit diverted from their pockets in order to keep the air clean for the community. It is not in the ethics of business to do so. Should, however, the Government grant a rebate of taxation or rates to firms which electrify their plant or do away with smoke emission, the business man would very soon take an interest in the matter. We are all the same.

We all go on burning coal fires as long as our neighbours do the same. But make it illegal to burn (and incidentally waste) coal in this way, and we shall not grumble.

I want to reiterate what I have said before in print. The time has come to demand not Smoke Abatement, but Smoke Abolition. Now that it is no longer necessary to pollute the air, it should be made a crime to do so. For it is a crime against ourselves. We need to make people conscious of what they have a right to demand, pure air and sunshine, and to demand it not as a treat on weekends and rare holidays, but as part of their daily lives.

DISCUSSION.

Mr. W. R. Gordon (Coal Utilisation Council) said that on reading Mr. Carrington's paper one rather got the impression that there were some people who thought that smoke was the only blotter-out of the sun. That, of course, was not true because with our changeable climate in this country, clouds often prevented us from getting full benefit from the sun. In any event, people who lived in climates where the sun shone with monotonous regularity were not by any means so hardy as our own people.

With regard to the managing director of a paper mill which emitted smoke, Mr. Gordon said that that was a case with which one of his engineers could deal satisfactorily. In and around Manchester 50 cases had recently been passed to the Coal Utilisation Council Engineer by the local Regional Smoke Abatement Committee. In another area their engineer had received a resolution of thanks from the local authority for the work he had done in abating smoke in textile mills.

He felt that smoke abolition was not yet practical politics but gradual reduction was certainly the best policy to follow. There were not, in any event, enough smokeless fuels to meet the demand which might be created in such circumstances and in any case there was considerable virtue in open fires, as the Chairman himself had said. Doctors very often recommended coal fires for certain classes of illness.

Apart from natural smokeless fuels, such as dry steam coal and anthracite, coal had to be burnt somewhere, say at gas or electricity works and was bound to give off smoke unless very costly means were adopted to prevent it. It was true that the nuisance might be only local, but that was no consolation to the people living in the locality.

So far as waste was concerned, it had to be remembered that not all the coal available in the country was by any means suitable for treatment by carbonizing.

Mr. James W. Stewart (Secretary of the Coal Merchants' Federation of Great Britain) said that the paper by Dr. Margaret Fishenden that morning, and the discussion which followed it, showed general appreciation of the fact that the smoke problem could be tackled

in a variety of ways, and that much could be done to reduce smoke from the coal fire by greater knowledge on the part of consumers of the way in which coal should be used, and of the different kinds of coals required for different purposes and for different appliances. In his view this was the right way of tackling the problem. The modern coal merchant recognized that smoke was one of his enemies, and did not require much education on the importance of reducing smoke so far as possible. Indeed, the coal trade was co-operating wholeheartedly, through the Coal Utilisation Council, in efforts to find satisfactory methods of abating smoke emission from domestic fires.

Mr. Carrington's paper, however, seemed to suggest that the proper method of tackling the problem was by way of abolishing, rather than by way of improving, the coal fire, and what he (Mr. Stewart) wished to do that morning was to urge on the Conference the importance of keeping a sense of proportion in approaching the problem of smoke. He was not inclined to attach too much importance to statistics of deaths occurring after fogs as offering conclusive evidence against coal fires. In this country fogs were experienced where coal fires could not possibly be held responsible, and there was far too great a tendency to attribute to the coal fire effects on health which were really due to the climatic conditions of the British Isles, and had little or nothing to do with smoke. Similarly, he thought the effect of smoke from the domestic fire on buildings and vegetation was exaggerated.

The merits, or demerits, of a coal fire must be judged as a whole, and not in relation to the isolated question of the smoke it produced. One would think from some of the remarks which had been made in the discussion that smoke was all that the coal fire produced, but it produced warmth, comfort and a sense of well-being as well, which far outweighed its drawbacks in other respects. Further, there was a living personality and sense of companionship about a coal fire which no other fuel could offer, and which should not be underestimated. This might be regarded as sentiment, but the science of psychology taught them that a sense of satis-

faction or well-being was just as important a factor in health as the external environment in which one lived and moved.

He would urge, therefore, that the problem of smoke should be regarded in its true perspective. A great deal could be done by educating consumers in the right use of coals and appliances, by research into methods of smoke reduction, such as was being carried out by the Coal Utilisation Council and the Fuel Research Board, by devising better appliances for consuming coal, and in similar ways. This was the true line of approach to the smoke abatement problem, as in this way they could make progress while at the same time retaining an institution which, with all its drawbacks, was a real asset in the national well-being.

Mrs. M. Jast spoke with special reference to the case of the miners. Previous speakers had emphasized the importance of taking no steps to effect smoke abatement which might result in using less coal and thus reduce the demand for the labour of the miners. She, on the contrary, urged that efforts should be made to secure alternative employment above ground. The question was too large to be dealt with in the time available—the implications too numerous to consider in detail. But in the light of the campaign for better physical fitness of the nation, it was urgently advisable to economize in the use of a material which involved such hard labour in unhealthy and uncomfortable conditions as coal mining. The comfort of the domestic hearth was purchased at an extravagant price by the waste of our most valuable national asset and the discomfort of the men at the coal face.

Fourth Session, Thursday, 15th October, 2-30 p.m.

Introductory Remarks by the Chairman, Sir Richard Gregory, Bart., F.R.S.

In two papers to be presented at the Conference this afternoon deal with two different aspects of atmospheric pollution. Sir Arthur Hill will describe the nature of the damage done to vegetation at the Royal Botanic Gardens, Kew, particularly in the glasshouses and during fogs, and experiments which have been made with the view of preventing it. Fogs are just as natural an effect in the Thames valley as rain-fall, but though no practical means yet exists of avoiding them, the deleterious constituents in them are due not to Nature but to man. The characteristics of these constituents have for many years been studied by Dr. J. S. Owens, whose pioneer work in this field of investigation is recognised as being of both scientific and practical value. While the problem at Kew is the conditioning of air which enters the glasshouses, that to which much attention is being given is the nature and dispersion of the effluents which leave flues and chimneys, and the means of purifying such discharges. Each of these aspects of atmospheric pollution is of interest and importance, and we are fortunate in having them put before us by high authorities. I will first call upon Sir Arthur Hill to read the paper by Dr. Metcalfe and himself upon their work at Kew.

THE EFFECT OF ATMOSPHERIC POLLUTION ON VEGETATION.

By C. R. METCALFE, M.A., Ph.D., Assistant Keeper, Jodrell Laboratory, Kew,
and

SIR ARTHUR W. HILL, K.C.M.G., Sc.D., D.Sc., F.R.S.
Director, The Royal Botanic Gardens, Kew.

(Presented by SIR ARTHUR W. HILL).

"As to Air and Water, they are certainly of almost as great importance to the life and prosperity of trees and vegetables—and therefore it is to be wished for and sought—that they be not infected with fogs and poisonous vapours or exposed to sulphurous exhalations. From all of which rain water that has had its natural circulation, is greatly free, so that it meets with no noxious vapours in the descent, as it must do passing through clouds of smoke and other volcanoes, continually vomiting out their acrimonious and sometimes pestiferous fervours, infecting the ambient air, as it perpetually does about London and for many miles adjacent.

—John Evelyn, in *"Silva,"* 1662.

It is often assumed that damage to vegetation caused by atmospheric pollution is a product of industrial development. No doubt this is for the most part true, but the words of John Evelyn cited above, which were written in the pre-industrial era nearly 300 years ago, show that some harm to vegetation was attributed to atmospheric pollution even at that time. It is interesting, moreover, that the chief types of pollution were then referred to as "sulphurous exhalations" and "smoke and soot," which are still the chief classes of substance mainly held to be responsible for damage at the present time, although they are now specifically described as "sulphur acids" and "phenolic substances."

At the end of the last century, Professor F. W. Oliver, F.R.S., made an intensive study of damage to greenhouse plants in foggy weather mainly at Kew and Chelsea. Since then frequent references have been made, in horticultural papers, to the damage caused by poisonous substances in the atmosphere, which are abundant over large

industrial towns, where the damage they cause to vegetation is especially bad in foggy weather.

Extensive researches on the effect of polluted air on vegetation have been carried out near Leeds, whilst in the United States a Commission was appointed to investigate and report on damage to vegetation and animals, alleged to be caused by the atmosphere being polluted by substances emitted from the works of the Selby Smelting and Lead Company in California. This Commission published a report—more than 500 pages long—in 1915, which embodies accounts of scientific experiments then carried out with toxic substances in the atmosphere, as well as a comprehensive survey of the damage which can be caused by them.

Some idea of the importance of the subject and the interest it has aroused is shown by the fact that the bibliography of original papers dealing with atmospheric pollution, compiled by the Selby Commission, contains nearly 100 references. The investigations cited are not only from America, but also from British and Continental sources.

On the Continent the effect of atmospheric pollution on vegetation has been investigated especially in Germany, and it is interesting to learn from Wieler's book (1905) on the influence of sulphurous acid on plants that sulphur-dioxide was detected in the leaves of plants as much as 8 kilometres from any known source of pollution.

Although phenolic substances and sulphuric acids are believed to be the chief categories of toxic substances in a polluted atmosphere, others such as hydrochloric acid, ammonia, metallic iron, iron compounds and, of course, arsenic, are also present, all of which are capable of exerting a detrimental influence on vegetation. Although much still remains to be discovered concerning the relative amount of damage to vegetation caused by each of these categories of substance, we do already know something of the way in which some of them affect vegetation, and of the symptoms they cause. These will now be considered.

Symptoms of Damage caused by Atmospheric Pollution.

Most people are familiar with the increasing unhealthiness in the appearance of the vegetation as an industrial area is approached. Trees, especially evergreens become stunted, lawns are poor in quality or almost devoid of grass, and only a few of the more hardy plants are able to survive. Although the poor development of the vegetation is only too familiar in some districts in and around London, the situation in the industrial areas of the Midlands and the North is much more depressing. In the neighbourhood of Leeds, Privet is stated to be deciduous, and near the centre of the town Cherry-laurel, Rhododendrons, Aucubas and Box are likewise defoliated in winter. On the other hand, Pinks, Carnations, London Pride, Iris and "Geraniums" are able to survive in spite of the unfavourable environment. "In Hunslet parish churchyard, surrounded on all sides by huge chimneys belching out smoke, even bent grass and the hardy *Poa annua* have been killed and the only sign of vegetation to be found is a few blades of grass still struggling for existence." In a neighbouring garden "the only flower is the *Iris*, which still blooms freely; the only shrub or tree is the Elder; its only fruit or vegetable is rhubarb; the only grass is twitch." Woods near Leeds have been killed, leaves of such trees as Lime and Sycamore develop brown blotches, whilst those of others such as Ash fall prematurely. Another symptom is that in badly polluted districts flowers are abnormally pale in colour.

Returning to districts round London, it is noteworthy that increasing difficulties are being encountered by horticulturists owing to industrial development, which has resulted in nurserymen moving further into the country, whilst the difficulty of cultivating Conifers at Kew has necessitated starting a collection of these trees in the more favourable environment of Bedgebury, some 10 miles east of Tunbridge Wells.

Although symptoms of the type of damage so far described are familiar to many, it is less generally realised that the poisonous substances present in a London fog are so

insidious in their action that plants grown under glass are often seriously damaged by them. Different kinds of plants show a marked variation in their resistance to this type of injury. It may, therefore, surprise many to know that in the Palm House and Temperate House at Kew, especially, bushels of healthy-looking leaves are gathered up every morning in foggy weather. Many kinds of Begonias may become defoliated in a night, whilst the leaves of others become burned before they fall off. The buds and flowers of Begonias likewise fall off, whilst the buds of certain orchids such as species of *Calanthe*, which always begin to open in November just when the weather is likely to become foggy, turn yellow and subsequently black, becoming detached without opening. The *Calanthes* should always provide a beautiful display at Kew at a time of year when there are few other flowers, if satisfactory provision can be made to prevent their being damaged by atmospheric pollution.

We may now turn our attention to the manner in which a polluted atmosphere can act on vegetation. The most obvious fact is that smoke, especially when under humid conditions it forms black fog, must reduce very greatly the amount of light which falls on the plants. Green plants devoid of light are unable to utilise the carbon dioxide in the air and elaborate it into carbohydrates, which are one of the chief forms of plant food. It is not, however, the particles suspended in the polluted atmosphere which alone reduce illumination, but the solid material which is deposited on the surface of the leaves in the form of an adherent scum, which can be removed only by wiping it off. This material, unless artificially removed, naturally reduces the illumination even when the weather is relatively favourable. It has been shown experimentally that if the sooty material is removed from a green leaf by wiping with a cloth, its efficiency for synthesising carbohydrates is considerably increased, but this treatment does not restore the full photosynthetic capacity to that of a similar leaf from a plant in an unpolluted atmosphere. This is because the stomata or pores in the surface of the leaf are clogged with sooty material thereby reducing or preventing gaseous exchange between the leaves and surrounding atmosphere from taking place.

Greenhouse plants suffer from reduced illumination as well as those in the open, because thick greasy deposits of sooty material are formed on the glass, and thus prevent much of the light from being available to the plants even on relatively-bright days. These deposits on the glass are so sticky at Kew that rain has little effect in washing the glass except during abnormally wet spells; it is therefore necessary to have our glasshouses scrubbed by hand, often two or three times during the winter—a costly and somewhat dangerous operation, especially in the case of the Temperate House with its two acres of glass roof.

It has already been mentioned that the sulphur acids in a polluted atmosphere are capable of causing damage to vegetation. To what extent exactly these acids harm plants growing in the open it is rather difficult to determine, because the sulphur acid content of the atmosphere tends to be especially high during foggy weather, when the harmful effects of the sooty substances also come into play and tend to mask the damage done by the acids. It is known, however, that burning of the foliage of trees and field crops can be caused by sulphur dioxide in extremely low concentrations, and experiments recently conducted at Kew indicate that sulphur acids are mainly responsible for the damage in glasshouses which occurs during foggy weather.

Before considering these in detail, it must be emphasized that sulphur acids, besides acting directly on plant foliage, can also damage vegetation indirectly by depleting the supplies of lime in the soil, which are essential for plant growth, as well as by inhibiting the activity of nitrogen-fixing and other bacteria which are an important constituent of the micropopulation of the normal soil. In industrial areas it is therefore especially important to ensure that the soil should be adequately supplied with lime.

Owing to the solubility of sulphur acids in water, it is not surprising that chemical analyses of rain water in industrial areas such as Leeds have demonstrated the presence of abnormally large quantities of sulphur compounds as compared with rain water from country districts.

During the course of the experiments conducted at Kew last winter, it was noted that rain, or more especially snow, which fell on the blackened roofs of the greenhouses carried a thick scum into the water tanks inside the houses. This dirty water was subsequently used for watering the plants, and it seemed reasonable to suppose that the impurities in this water might be responsible for some of the damage to the plants. Samples of the water from three of the houses—collected after a period of snow when a great deal of scum was washed down—were therefore analysed at the Government Laboratory. The water was filtered before the analyses were made, but the surprising fact is that, from the point of view of dissolved matter, all the samples were found to be purer than water supplied by the Metropolitan Water Board. The pH values of the greenhouse samples were, however, slightly lower than that of the Metropolitan Water Board supply. It is also of interest to recall that the most impure of the three samples referred to was used, without being filtered, to water the soil and spray the foliage of a type of *Begonia* that is especially liable to be damaged during foggy weather, but the symptoms usually associated with foggy conditions were not reproduced.

In spite of these rather surprising results, however, the use of roof washings for watering plants in industrial districts is not to be recommended unless the water can first be filtered.

The evidence collected at Kew last winter (1935-36) has confirmed the view that the principal cause of the burning of foliage, and disarticulation of buds and leaves of certain greenhouse plants in foggy weather, is the sulphur acids operating directly on the aerial parts of the plants in a very humid environment. It also seems probable that the main form of sulphur which is responsible for this damage is sulphur dioxide, which in solution forms sulphurous-acid.

The reasons which lead us to this conclusion are as follows: in the first place the action of a fog is extremely rapid, and it is by no means uncommon for healthy-looking Begonias to be completely defoliated in a single night. Such rapid damage cannot well be due to the deposition of solid matter, of which comparatively little falls on the plants in the houses. Also there appears to be no correlation between the degree of solid pollution in a fog and the amount of the observed damage.

Records of solid atmospheric pollution are kept at Kew Observatory, which is situated on the ground adjoining the Royal Botanic Gardens, and these show that on December 23rd, 1935, there was a very high degree of pollution; yet, during this period, although some damage was noticeable in the greenhouses this was by no means so serious as that caused by a more prolonged fog in January, 1936, when the solid pollution was considerably less. This definitely corroborates the experience of Kew gardeners, gained over many years, that the maximum damage to greenhouse plants is not necessarily caused during an especially dense fog.

It has been observed, during a dense fog, that although a certain amount of visible pollution enters the houses through cracks between the panes of glass and similar places, the solid matter suspended in the atmosphere is very much less dense than it is outside. This is probably due to the heat from the hot-water pipes causing the aqueous particles of the fog to evaporate on entering the house so that the fog tends to disperse; but it must be pointed out that any sulphur dioxide dissolved in the fog droplets would be liberated by the warmth in the form of a gas, and so be able to enter the leaves, via the stomata, and act on the tissues of the plant.

The exact form in which the sulphur acids act on plants appears to be of marked importance, as is shown by the following considerations: on several occasions an oleum mist was liberated in an experimental greenhouse at Kew, which was filled with plants especially susceptible to fog damage. A fine spray of water was also played on the plants at the same time. The atmosphere in the house became exceedingly unpleasant, and any one entering experienced a feeling of intense suffocation. The process was repeated at intervals so that the plants were subjected to strong sulphurous fumes for many hours, yet no harm was done to them.

On the other hand, it has been found that if Begonias are placed under glass

bell-jars, together with dishes of extremely dilute sulphurous acid, the symptoms characteristic of fog damage are reproduced. Plants of *Begonia foliosa*, for instance, can be completely defoliated during a single night.

It will be appreciated that under such experimental conditions the plant is subjected to the action of a very small concentration of sulphur dioxide in a more or less saturated atmosphere, much in the same way as might be found in a greenhouse during foggy weather. It is also interesting to note that those Begonias which are most liable to be damaged during foggy weather are the same as those which succumb most readily to the sulphur dioxide treatment.

Begonias such as the varieties of "Gloire de Lorraine," which are fairly resistant to fog, are only affected after more prolonged treatments, or rather more concentrated sulphurous acid. When leaves have been coated with vaseline before the treatment with sulphurous acid they are found to be more resistant to the action of the poisonous gas than are untreated ones. This demonstrates clearly that the poison operates directly on the leaves.

Susceptible Begonias have also been kept under bell-jars in a saturated atmosphere, and in some instances the bell-jars were covered with black paper in order to reduce the amount of light reaching the plants. In these circumstances the Begonias were found to shed a certain number of leaves, especially when light was excluded, but in no instance was there a sudden prolific leaf fall such as occurs when sulphurous acid is used. High humidity and reduced illumination thus appear to be favourable to, but not entirely responsible for, premature leaf fall. From recording thermometers and hygrographs placed in some of the houses at Kew, it has been shown that fog damage last winter was not associated with sudden falls in temperature but, on the other hand, the humidity remained continually at a very high level during a fog because it is inadvisable to give the houses their normal daily airing by opening the ventilators. The conditions in the houses during a fog are, therefore, especially favourable for the operation of sulphur dioxide. Here again these scientifically ascertained facts confirm the experience of practical gardeners that in order to prevent damage in foggy weather greenhouses must be kept as dry as possible; also that rather low temperatures are desirable.

Remedial Measures.

There is only one way in which vegetation can ultimately be saved from the effects of atmospheric pollution, and that is by taking steps to prevent poisonous substances from being liberated into the atmosphere. This desirable end may be approached, but can hardly be attained since (1) the purification of flue gases involves expense which the hard-pressed manufacturer is not always willing to incur, and (2) because the general public cannot easily or suddenly be induced to cook their meals and warm their houses by new methods. Fortunately it is realised nowadays that the emission of black smoke from factory chimneys is wasteful as well as deleterious, and this nuisance shows some signs of declining.

One of the most serious sources of atmospheric pollution, however, continues to be that due to the burning of raw coal in domestic fireplaces. The increased use of gas and electricity for domestic purposes has no doubt checked the pollution of the atmosphere with solid matter to some extent, but on the other hand the number of houses and chimneys around London have increased enormously in recent years.

It must be remembered that, even if smokeless fuels are used, sulphur dioxide is still emitted. The strongly sulphurous smell given off when coke and some kinds of anthracite are burned in domestic water-heaters is sometimes very pronounced. It therefore seems likely, even if smokeless fuels become more widely used, that the danger to vegetation resulting from sulphur dioxide pollution will increase, though there would be little or no soot deposit. That this supposition is accurate is unfortunately borne out by the fact that the sulphur pollution of the atmosphere round London has actually increased during the last ten years although sulphur gases can be and are being

successfully removed from large-scale electric generating stations. This being so, it seems probable that some advance towards a cleaner atmosphere could be attained if (1) the price of electricity could be reduced sufficiently to bring it within the means of the poorer members of the community and (2) if they could be induced to use this source of energy for adequately and cheerfully warming their homes.

Since we must evidently await with patience the necessary improvements from the engineer, and the enlightenment of the general public, in order to effect a reduction in the amount of atmospheric pollution, we can meanwhile apply more immediate practical remedies wherever and however possible. It has already been pointed out that one consequence of the ill effects of a polluted atmosphere is that a number of cultivators have been forced to move out into the country, and many more will probably follow their example. This migration involves much expense and waste of time in developing new nurseries and market-gardens in districts which will no doubt become urbanized soon after the cultivators are well established in their new surroundings! In addition, the cost of transporting the produce to the town markets is bound to increase in proportion to the distance the cultivators are driven into the country, and the vegetables, etc., will lose much of their freshness. It would be well in drawing up plans if sites suitable for horticulture could be reserved in situations which, on account of their elevation and the direction of the prevailing wind, are likely to be fairly unpolluted.

Where cultivation is carried on in greenhouses, it might be worth while to incur the necessary expense to try and reduce the pollution damage without moving into new surroundings. This applies especially to glasshouses belonging to parks and pleasure gardens in large towns, and also to the Royal Botanic Gardens, Kew, where we attempt to cultivate many rare and valuable tropical and sub-tropical plants in a district which is becoming progressively more industrialized. Professor F. W. Oliver, in his survey of the damage done to greenhouse plants in foggy weather, made recommendations for the prevention and reduction of the damage. He advised that greenhouses should be constructed with as few cracks in them as possible, and that purified air should be introduced in foggy weather through special ventilators. He also advocated the use of artificial light. At that time a Mr. Charles Toope put on the market a device known as "the patent fog annihilator," which was intended for use in greenhouses, but, in spite of Professor Oliver's favourable report, the method does not appear to have been extensively tried. The idea was that hot air should be allowed to escape from the houses through special ventilators in the roof, whilst fresh air would be introduced through ventilators packed with charcoal, situated just above ground level. Impurities in the air entering through these ventilators would be absorbed by the charcoal, and the clean air would then be warmed by being passed over the hot-water pipes inside the house.

In co-operation with H.M. Office of Works, it is hoped to try a modification of this proposal at Kew this coming winter. Filtered air will be forced into the houses by electric fans through fabric and charcoal filters and passed over the hot-water pipes to be warmed. The clean air thus introduced will, it is hoped, so raise the pressure inside the houses that unfiltered, foggy air will be prevented from entering through cracks; but we do not yet know how successful this method may be.

Professor Oliver also noticed that, when houses were completely covered with canvas during foggy weather, the plants suffered less. This may be due to the covering of the cracks between the panes of glass or to keeping the temperature rather higher. He also tried chemical vapours in the houses for the neutralisation of the acid, but was not much impressed by his results.

At Kew during last winter we carried out experiments for the prevention of damage by fog. Two chief methods were employed:—

1. Keeping the air in motion by means of small electric fans.
2. Placing near the hot-water pipes dishes of 2% ammonia solution in the houses.

The experiments with fans gave quite promising results, although they did not entirely prevent damage by fog. In one of the orchid houses, where fans had been

installed, a batch of *Calanthes* which were then coming into flower remained quite undamaged during several minor fogs and one severe one. The fans appeared to be beneficial also during dull weather, when it was not appreciably foggy. Other *Calanthes*, however, in an adjoining house where there were no fans were very badly damaged.

Our hopes were somewhat shaken during the severe and prolonged fog which we experienced in January, when *Calanthes* which were being fanned and had resisted earlier fogs slowly succumbed. Fans were also employed in the Begonia House (No. 8) with good results, where in previous years most of the plants always shed their leaves in foggy weather. It seems probable that the fans act beneficially by increasing the evaporating power of the atmosphere under the very humid conditions which prevail in foggy weather, and so prevent the sulphur acids from acting on the plants.

The use of ammonia also appeared to give promising results in another Begonia house, but further experiments both with fans and with ammonia will have to be carried out before any definite recommendations can be put forward for their adoption.

No experiments with artificial light to supplement the reduced daylight caused by atmospheric pollution have yet been tried at Kew, but it is hoped to do so. Elsewhere results have been conflicting, but this may be due to the varying conditions under which the work has been done and also to the use in some circumstance of unsuitable sources of light. The main object should be to increase the illumination with light of suitable wave-lengths without raising the temperature. Mercury vapour lamps are generally very harmful and so are ordinary gas-filled lamps, since, to be of sufficient candle-power to be effective, they emit so much heat that the plants get "drawn up." The most promising results with light are likely to be achieved with Neon lamps, which are now reasonably low in price. These lamps emit very little heat and have been employed in Holland and also at Salford for irradiating plants in dull weather with beneficial results.

One cannot do more, in a short paper, than indicate the type of damage to vegetation which may be caused by a polluted atmosphere, and many details have had to be omitted. It will, nevertheless, be appreciated that fog damage has far-reaching consequences on our plants and any remedies that may be possible are of real economic importance. Close co-operation between botanists, horticulturists, chemists and engineers, all endowed with imagination, is necessary for the study and solution of the many problems involved; for the damage done is so great that every effort should be made to bring about its prevention.

REFERENCES.

1. ASCROFT, F. W. "The Conservation of the Nation's Vegetation." The Effect of Smoke on Plant Life.
2. COHEN, J. B., & RUSTON, A. G. "Smoke: a Study of Town Air." London, Edward Arnold & Co., 1925.
3. CROWTHER, C. "Town Smoke and Plant Growth." Journ. Roy. Hort. Soc. 38, 1912-1913, 461.
4. HOLMES, J. A., FRANKLIN, E. C., and GOULD, R. A. "Report of the Selby Smelter Commission." Bull 98, Dept. of Interior, Bureau of Mines, Washington, 1915.
5. LESSING, R. "The Sources of Atmospheric Pollution." from Proc. National Smoke Abatement Soc. 1935.
6. OLIVER, F. W. "On the Effects of Urban Fog upon Cultivated Plants." Journ. Roy. Hort. Soc. 13, 139, 1891.
7. OLIVER, F. W. *ibid.* 16, 1, 1894
8. POESCH, G. H. "Supplementary Illumination from Mazda, Mercury and Neon lamps on some greenhouse plants." Proc. Amer. Soc. Hort. Sci. 33, 1935, 637.
9. Roodenberg, J. W. "Kunstlichtkultur." Angew. Bot. 13, 162.
10. Tjebbes, K., and Uphof, J. C. Th. "Der Einfluss des elektrischen Lichtes auf das Pflanzenwachstums." Landwirtschaftliche Jahrb. 51, 2, 1921, 313.
11. WIELER, A. "Untersuchungen über die Einwirkung schwefliger Säure auf die Pflanzen." Berlin, 1905.

FUTURE DEVELOPMENTS IN THE INVESTIGATION OF ATMOSPHERIC POLLUTION.

J. S. OWENS, M.D., A.M.I.C.E., M.I.Mech.E.

Existing Methods.

A short reference has already been made to the standard methods adopted in the Investigation into Atmospheric Pollution in this Country, and will be found in the Exhibition Handbook. It is, therefore, unnecessary to deal at any length with the subject here. The Investigation has now been carried on for about twenty-five years, and the methods adopted were necessarily such as could be used generally in the Country. The conditions such methods usually had to satisfy were that they should be simple and easily operated without too much skilled attention; the cost involved should be small, and the degree of accuracy sufficient for the purpose. Complicated methods calling for much laboratory work or the attention of skilled assistants would not be used, except in a few places and, however attractive from a scientific point of view, would never be adopted sufficiently widely to provide the information required.

Necessarily these conditions imposed upon the methods certain limitations. For example, a high degree of accuracy was not considered essential, but it should be sufficient to give reliable results. A higher accuracy than this, at the expense of greater complications and cost in the method, is not desirable and is likely to defeat the chief object.

During the last year the Research Committee on Atmospheric Pollution have been enabled to devote more money to research, and a whole-time assistant has been employed. This naturally permits the carrying out of investigations otherwise impossible, and the development of new methods.

As the general principles of the methods adopted are doubtless understood by those present, and reference can be made to the short note in the Exhibition Handbook, it will be best to devote any available space to considering possible future developments. It is, however, to be understood that what follows is simply an expression of the Author's views and not an official pronouncement.

It will be convenient to deal with the subject in two main sections:—

1. What would be the most useful lines for future investigation, and
2. What new methods or apparatus are required.

SECTION 1.—SUGGESTED INVESTIGATIONS.

(a) *Grit Deposits.* Very often a place suffers from the deposit of grit and it becomes of great importance to know what is the source of such. Sometimes this is obvious, but more often strong arguments can be put up against any particular source being responsible. In this connection there are two developments which might very well be carried out. 1. Find some means of ascertaining the direction from which the grit comes, and 2. An examination of deposits with a view to finding simple criteria for identification. This should be by no means an impossible task, and indeed a great deal can be done at present, but what is now suggested is a specific investigation directed towards making available known means, or finding such where not known, for identification of the sources of all kinds of grit deposit. The methods of doing this are perhaps best dealt with in the discussion which may follow, as space does not permit to do more than make a brief reference here.

It may, however, be stated that there is good ground for believing such an investigation would lead to practical results, *e.g.*, It is possible now, by microscopic examination to state whether the deposit is due to combustion products, or just fragmentary dust. Flue dust from pulverized coal furnaces is often quite characteristic owing to the high proportion of spherical particles of fused ash. The size of the particles is also important, as dust particles from pulverized coal are usually small, and fairly

uniform, whereas from mechanically-fired furnaces, the dimensions may be quite large. Cement kilns emit characteristic dust, containing hollow spherical globes of microscopic dimensions. The presence of angular unburnt coal particles is often easily recognized and indicates coal dust from some unloading station or store. The use of polarized light as in petrological methods, gives us another line of attack.

These are a few examples of the lines on which the investigation might be carried out, but it involves a considerable amount of time and work to make it all exhaustive.

(b) *Drift*. The examination of the drift of smoke pollution from its source and in particular in specific cities how much pollution is due to local sources and how much drifts to the city from outside, would be a very valuable enquiry. Anyone familiar with the manufacturing area in the Midlands is aware that there is a considerable smoke haze to be found drifting with the wind outside of cities, and when a city is interested in purifying its atmosphere, it becomes important to know how much of the smoke pollution is contributed by its neighbours. How this is to be done is a very suitable subject for discussion.

An examination of the condition of the air at some of our seaside resorts would be very enlightening. When such places grow into cities, the air which the inhabitants have to breathe is often no better than that of any inland city. It may even be worse owing to the concentration of invalids under the impression that they are getting sea air, whereas it is only on occasions when the wind is blowing from the sea that they get anything but ordinary city air. During land winds they are in no better position than in an inland city. It is perhaps too much to ask that our seaside resorts should engage in an investigation of their own atmospheres, but from the point of view of the people who frequent such resorts, it would give very valuable information.

(c) *Cost*. A good deal is published in the popular press about the cost of smoke to the Country, but it is usually based upon a statement by some enthusiast, who applies more enthusiasm than accuracy in his estimate, or simply quotes someone else's figures. It is a very difficult thing to give an accurate estimate of the cost of smoke, because it is so wide spread in its effect, and so very elusive when one attempts to obtain a result. However it is not impossible and has been attempted with some success in Pittsburg in 1912* and in Manchester in 1918,† but there has been no recent authoritative attempt in England, and it is suggested now that it would be a most valuable investigation. The cost is made up of the loss to the smoke maker, as well as to the people who have to live in the atmosphere polluted by his smoke. There are increased laundry bills, cost of painting, protecting metal work, cleaning and repapering walls, renewing curtains, artificial lighting and so on. There is the unknown loss also in connection with public health. Although all these are somewhat difficult to ascertain, it is felt that it would be a valuable work if some authoritative body would undertake such an investigation at the present date. Large sums are known to be lost, but there is so much uncertainty and indeed doubt in the mind of the public as to the accuracy of figures quoted that some reasonably reliable estimate would certainly be of great value in the campaign for smoke abatement.

To obtain such an estimate, a scheme would have to be worked out for obtaining the necessary information, and it appears probable that the most satisfactory method would be to prepare a suitable questionnaire and to obtain the co-operation of certain bodies in getting answers to the questions, *e.g.*, the effect upon health might be dealt with by Medical Officers of Health; cleaning by proprietors of large blocks of flats or hotels; the Transport Board might co-operate to obtain an estimate of the effect on transport, such as during city fogs in the streets and on railways. Technical Institutions, as the R.I.B.A., or Inst.C.E. might deal with the effects on structures. Some large stores, as the Army & Navy, or Selfridges might give an estimate of cost due to injury to fabrics. The general idea is to enlist the services of such bodies as would be most likely to have, or be able to obtain, the information required.

* Mellon Institute, University of Pittsburg, Bulletin No. 4.

† The Black Smoke Tax, Manchester Air Pollution Advisory Board, 1919.

(d) *Loss of Daylight and Ultra-Violet in Cities.* It is not necessary to say much as to the desirability of ascertaining with reasonable accuracy the effect of our city smoke in robbing us of the health-giving daylight and ultra-violet. We know that much is lost in this way, but so far we have not been able to agree upon a sound method of measuring the loss, which might be recommended as standard for general use in the investigation of atmosphere pollution and its effects.

Many attempts have been made to find a method of measuring daylight which could be used fairly generally, and a brief reference to some of these may be made.

Sunshine records by the ordinary standard methods do not give this information, although the results are valuable as indicating the amount of direct sunshine lost.

A method has been in use in some places in which a 2 oz. glass bottle containing a solution of potassium iodide, acidified with sulphuric acid, is exposed to the light in the presence of air, and the amount of iodine liberated is taken as the measure of the daylight received. This method is only very approximately correct; the glass bottle transmits very little ultra-violet, there is considerable loss of light by reflection from the surface, and it is, like other methods, sensitive to the presence of surrounding obstructions.

Photo-electric methods have also been tried, but they tend to develop into rather complicated and costly apparatus.

The action of light on photographic paper appears to be the most hopeful means to utilize, and this has also been experimented with. There are numerous difficulties to be overcome in any apparatus used for this purpose. The presence of obstructions restricting the area of sky visible has an important effect, so that an apparatus exposed in any open space in a city is likely to have a considerably restricted area of sky visible.

We have also Dr. Leonard Hill's Acetone Methylene Blue Method, in which a blue dye is exposed in small quartz tubes, and the fading measured by a standard scale gives an indication of the amount of ultra-violet received. The method involves some difficulties, as referred to above, and it is found necessary to expose glass tubes as well as quartz, and take the difference between the glass and quartz tubes as the fading. Again, it has been found that if not read immediately, but left overnight, there is a tendency for the colour to return.

(e) *Ventilation.* The subject of ventilation is inevitably linked with that of atmospheric pollution. The function of ventilating is to provide clean healthy air for people to live in within their buildings. Outside the buildings, nature attends to the matter by providing sufficient wind to carry away impurities. Within our buildings, however, for some strange reason, the calculation of necessary ventilation has been, until recent years, based upon a complete fallacy—that the concentration of CO_2 tells us if the air is pure enough to breathe. CO_2 is a completely harmless gas and not only that but it is no indication of the presence of other harmful materials in the air. Hence it is gradually becoming more and more appreciated that proper ventilation implies the removal of the solid or liquid impurities which are suspended in the air. Hence the number of systems for air conditioning and filtering. Naturally, it is very difficult to remove the very finely suspended matter from the air. Hence false impressions as to the value of filters may easily arise. When it is considered that except in very isolated cases of gas contamination and the like, the real need for ventilation of buildings and rooms arises from the presence in the air of innumerable bacteria and suspended dust particles, it will be seen how important it is to change our ideas as to the measure to be applied to ascertain if the ventilation is adequate. It is not suggested that it is unnecessary to assure a sufficient supply of oxygen and removal of carbon dioxide but rather that the obvious need for this has blinded us to the really greater danger of being forced to breathe dust and bacteria-infested air. This is an aspect of the matter which has a profound bearing upon public health, and is, therefore, one of great importance.

(f) *City Smoke Fogs*. Only a very brief reference to this subject can be made, sufficient to enumerate a few lines of investigation which would be of use:—

1. We do not know very much, except in general terms, of the way in which the smoke concentration during such fogs varies with height above ground under different conditions. This is an investigation which is required, but would involve rather heavy expense, as some form of aircraft would have to be used.

2. It appears possible that an investigation of the condition of the air over a large city just before a smoke fog might throw some light on its exact causes. It is usually possible by observing the automatic filter records after midnight to detect a definite failure of the air to clear up before a smoke fog, as it normally does. Thus, dark records at this time usually mean a smoke fog during the day, and thus we have a warning in time to examine the nature of the predisposing condition. Here again, the same objections of cost hold good.

(g) *Silicosis*. This is mentioned more for the purpose of completeness than to suggest a specific investigation. The dust which causes silicosis is a form of atmospheric pollution, and is produced in the drilling and blasting of certain rocks during mining operations. Here future developments will probably take the form of the reduction of dust already suspended in the air and the prevention of emission of dust from drill holes during rock drilling. This latter has been attempted by:—

1. Wet drilling, i.e., hollow steels with a stream of water forced to the cutting edge.
2. The wetting of the dust in drill holes by a solution forming a foam and with a low surface tension.
3. Sucking the dust away over the holes by suitable hoods and piping.

SECTION II—METHODS OF OBSERVATION AND APPARATUS REQUIRED.

It will be realized that this is not a description of the methods and apparatus now available, otherwise the title including the expression "Future Developments" would be a misnomer. It is rather a collection of suggestions, for those who can make use of them, for new apparatus or methods of observation required. With this proviso we may now proceed.

An Automatic Filter operated electrically. One of the most fruitful methods of measuring the smoke pollution of cities has been the "automatic filter." It enables us to get a regular series of observations during the whole day of the concentration of sooty matter in the air. It is unnecessary to say more on this here, as the apparatus is well known, and has been fully described elsewhere.

The recent increase in the use of electricity and the standardization of supplies gives us now a source of energy not available when the original water-operated filter was designed. There is, therefore, a need for an electrically-operated instrument, and to be of use it should be simple and reliable. It should filter a standard volume of 2 litres through a disc of $\frac{1}{8}$ " diameter in order to give results comparable with previous records. It should, however, be possible to vary the volume filtered so that the standard 2 could be increased to 4 or 8 litres to provide for places with little smoke pollution and for the summer season when smoke production is small.

The final, and probably the most important condition, is that the apparatus must cost as little as possible, or it will not be used at all widely. It is suggested that a cost of £10 should not be exceeded. Such an instrument would probably be much more extensively used than the existing water-operated one, which costs about £37.

Measurement of Daylight and Ultra-Violet. The photo-electric method has been developed for daylight by the N.P.L. and has been in use there for some years. Dr. Dobson has also worked on this method in an apparatus for the Research Committee and has also made experiments with a photographic paper method. These latter usually take the form of apparatus in which a piece of sensitized paper is exposed to the light under an opaque plate, perforated with a line of small holes. Above

these holes, is an optical wedge of neutral-tinted glass, which allows light to penetrate in a gradually increasing quantity from one end of the wedge to the other. The density of the wedge may be adjusted so that with the brightest light conditions, spots appear on the paper under the whole length of the wedge up to the thickest or densest end. While, with any lower degree of illumination, there would be no mark at the dense end, but the last of the spots would be under a thinner or less dense part of the wedge. Thus by counting the number of spots appearing on the paper, a measure of the amount of light received is obtained. Such a method may be used for ultra-violet radiation also, provided the wedge is transparent to ultra-violet. When used for this purpose, the wedge is covered by a glass which transmits ultra-violet, but little or no other light of an actinic kind.

There is some difficulty in obtaining a wedge which is transparent to ultra-violet, as ordinary glass would not do. Hence as special material must be used, and this may not possess the quality of permanence, which is required.

Dr. Ashworth has designed an instrument in which the place of the wedge is taken by sheets of fine wire gauze and the graduation obtained by using different numbers of superimposed layers of gauze. In the Authors' instrument, the necessity for a wedge is done away with and its place is taken by a series of holes in a plate. In this case, the graduation in the light admitted to the paper is obtained by varying the diameter of the holes in this plate. Each of these graduated holes, which admit light, is at the upper end of a cylindrical cell or tube, the lower ends of which tubes terminate in uniform holes in contact with the sensitized paper. In this instrument when used for ultra-violet a cover of ultra-violet glass is placed above the holes which admit light to the cells. When used to measure daylight, this cover is formed of transparent glass. In all of these instruments, the number of spots which appear on the paper is a measure of the amount of light received.

There are difficulties in all such instruments, such as deciding on and maintaining constant the amount of sky from which it is desired to obtain light. When provided with a flat horizontal covering glass this type of apparatus receives no light from near the horizon, as it is all reflected from the glass surface. Again, there is the question, is it advisable to receive in such apparatus, direct sunlight, or to exclude it? If it is decided to exclude it, the apparatus may be set facing north at about 45 degrees.

To obtain a record from the whole sky, an opal glass globe may be used as a cover for this type of apparatus, but this involves considerable difficulties—while effective enough for ordinary daylight, such a globe would not transmit much ultra-violet. In the Author's apparatus, when it is desired to include direct sunlight, the under surface of the covering glass is ground, so that it becomes illuminated by the sunlight if exposed to such, while if it is desired to collect from the whole sky a hemispherical cover glass can be used. For ultra-violet this would be of quartz.

The above will give an idea of the present position of daylight and ultra-violet measurement.

In view of the need for simplicity and low cost, it would seem that the photographic paper method is most likely to prove satisfactory. In all instruments in connection with Atmospheric Pollution, cost plays a vital part, since unless this is low, the number used will be so small that only comparatively few results are likely to be available. Further, as already mentioned, it is important not to complicate apparatus too much in the attempt to get a greater accuracy than is called for by the object in view.

Directional Apparatus for SO₂. When there is any serious pollution by sulphur gases, it usually becomes very important to find the direction from which it comes as a step towards locating the source. One way of attempting this which is now being tried is to set up a short cylinder coated with lead peroxide paste and surrounding it, a revolving hood with a window at one side. The hood fits closely over the lead peroxide cylinder, but does not rub, and it is revolved by a wind vane in such a way as to keep the window facing the wind. After exposure for a suitable time, the lead

peroxide coated cylinder is removed, and its surface divided into a suitable number of sections, *e.g.*, North, South, East and West quadrants, and the degree of sulphation of each section is estimated. Obviously a high degree of sulphation on any section, such as the South quadrant, might result either from a prevalence of southerly winds or a source of sulphur in the South. If the wind blew from all directions for equal times, which it does not, we might conclude that the source of sulphur was in the South; this is only one of the difficulties to be dealt with in interpreting results. A record of wind direction must therefore be kept, and means for obtaining such a record may be embodied in the apparatus.

There is also some difficulty due to the necessity for the outer cylinder, or hood, with its window, to revolve very freely so as not to affect the movement of the wind vane. This in turn, implies a clearance between the outer and inner cylinders and the wind can penetrate this space and thus carry the sulphating action beyond the edges of the window.

Experiments are now being made with the apparatus by Dr. Meetham, the Committees' Research Assistant, at the Building Research Station. It is generally agreed that sulphur is the chief cause of decay of building stone in cities and this method aims at measuring the activity of attack on such stones by sulphur-laden winds from different directions.

Directional Deposit Gauge. When there is a heavy deposit from the air in a particular place, the question—"Where does it come from?" invariably arises. It must be confessed that we have no really effective apparatus which would receive deposit when the wind is in one direction, and refuse it when it is in another. The capacity to do this must be the basis of any directional deposit gauge. The problem looks simple at first sight; it would appear that all you require is a ring of gauges with a revolving cover which exposes only one gauge at a time, the cover being connected to a wind-vane which determines which gauge is exposed. In spite of its apparent simplicity, the problem simply bristles with difficulties—to mention a few of them:—

1. The wind would rarely be kind enough to set the cover so that only one gauge was exposed. It would more often expose part of two.
2. The area of collecting surface must be fixed and known. It becomes very awkward when the revolving opening only partially exposes a gauge.
3. Since free movement of the cover is essential, this means a clearance and imperfect closure of gauges nominally closed, and these are kept filled with air carrying suspended matter which deposits in the gauge vessel, invalidating results.

To illustrate these difficulties, an attempt by the Author to estimate the directional effect may be described. Three standard gauges were set up close together, each provided with a lid and the usual bottles below for collecting whatever fell into the gauge. Calling these gauges A, B, and C, A had its lid removed when the wind was in a certain suspected direction, B remaining closed. When the wind came from another direction, A was closed and B exposed. Gauge C was exposed for all the time when either A or B was uncovered; this was to be a check on the results of A and B as, if working correctly, the sum of the deposits in A and B should be equal to that in C. Briefly, this was not the case, and there was no reasonable agreement until certain further precautions against leakage of air into the nominally closed gauges were taken. These were (1) the covers were made airtight by a spongy rubber ring on each, and a clamp for holding down, and (2) the air outlet tube from the bottle was continued inside each bottle to the bottom, and a seal of a little distilled water added. This was to prevent changes of the air in the bottle due to temperature or pressure changes. It was only after these precautions were taken that a reasonably good agreement was found between C and the sum of A and B.

This question of the direction from which polluting material comes is perhaps one of the most important, when we have to deal with deposit in specific places. The same question is involved if we wish to find, in a city, what proportion of the

atmospheric pollution comes from the city itself, and what from neighbouring cities or works. It is, therefore, a very important question, and a reasonably accurate directional gauge would be a great help in many such problems.

Measurement of Hourly Concentration of SO₂. As many of you are aware, a method of estimating the sulphur concentration in the air has been in use for some time. In this, a measured volume of air, 70 to 100 cu. ft., is drawn through a solution of hydrogen peroxide, or its urea equivalent "hyperol"; the SO₂ is oxidized to sulphuric acid and this is estimated by titration with an indicator. The results give the average concentration over 24 hours, which is the period for which the apparatus is usually run; this has little relation to the maximum concentration. Some two or three years ago, a modification of this was devised by Mr. Jackson, of Middlesbrough, which gave the SO₂ concentration for each hour. This was tried out, and gave, under his care, very satisfactory results; it showed in one case that while the average over 24 hours was 0.485 p.p.m., the highest hourly concentration in the same period was 2.00 p.p.m.

The original apparatus was kindly handed over to the D.S.I.R. for the purpose of the research into Atmospheric Pollution, and it promises to develop into a most useful instrument. As in the standard apparatus referred to above an aspirating pump and meter are used. There is an arrangement of two brass discs, one above the other, like two coins laid on the flat. The bottom disc is fixed, and the upper one rests on it, and is revolved 1/24 of a revolution each hour by means of a spring and a clock with a suitable escapement. The bottom disc has two rings of 24 holes communicating below with 24 glass test tubes suspended from the disc, and above with an inlet and outlet tube, fixed to the top disc. Thus, when the discs are in a suitable position, the air is drawn through one of the glass test tubes containing hydrogen peroxide, and after an hour the upper disc is revolved until the next test tube is brought into a similar position and receives the air. At the end of 24 hours, each tube has had a known volume of air passed through it, and the solution in each is then titrated as in the standard apparatus. In this way an hourly estimation is made of the concentration of SO₂. The results with the experimental apparatus compare well with those obtained with the standard Volumetric Method. It is anticipated that when the final apparatus is available, it will give very valuable information—especially in places where there is a marked variation in the concentration of SO₂ at different times of the day or night.

DISCUSSION.

Dr. W. Powell Phillips (Deputy M.O.H., Cardiff) said that Dr. Owens had introduced into his paper a reference to the subject of ventilation. This was a matter which had a very far-reaching public health interest, especially with regard to places of entertainment such as the cinema. The use of the carbon dioxide content of the air as a measure of purity was condemned, and very rightly so, as it could only be looked upon as giving some indication of the amount of air change which was taking place. In view of the importance of this question it would be of interest to have Dr. Owens' views as to what was the most satisfactory means of estimating the efficiency of ventilation.

Dr. J. R. Ashworth said that as Dr. Owens had invited suggestions for the solving of certain problems one of which was to find the direction from which smoke pollution came,

he would like to refer to an apparatus he had used for one or two years which had been found to serve the purpose.

It was a vessel of the deposit gauge type, but without the usual outlet, over which there was a cover which was capable of revolving and could be oriented by the wind by means of a vane. A tube about 5 inches in diameter was let vertically into the cover, the upper half being bent at right angles so as to prevent an opening to wind blowing along horizontally. The cover had a deep flange and the apparatus was surrounded with a high metal ring-fence so that the deposit vessel was very thoroughly protected from stray impurities accidentally getting into it, thus ensuring that the only pollution entering came through the orifice provided. If, now, the deposit vessel was divided into two, four or more equal compartments, and their orientation was known, the amount of pollution found

in the compartments would indicate the amount brought by the different winds provided that the duration of the wind in each direction had been observed and so that the quantity deposited in any compartment could be reduced to what it would be for a given unit of duration, say, a day.

Two forms of the apparatus were described in "Smoke and the Atmosphere," by the author.

Mr. Thomas M. Ashford (Glasgow) referred to the effect of wind drift on smoke pollution. A previous speaker had stated that invariably industrial and working-class districts of any neighbourhood were the dirtiest from a smoke pollution point of view. In Glasgow very much the opposite was often experienced, and certain of the highly residential districts of the West End were found month by month to be the heaviest in precipitated impurities—a circumstance which had on occasion called forth surprised and indignant comment.

In Glasgow, prevailing wind direction had a marked effect. The precipitation at two sanatoria, one eight miles south-west of the city and the other six miles north-east, was noted, the prevailing wind being south-west. In the former case the average precipitation was only half of that experienced at the latter institution in the direct path of the drift over the city.

In an attempt to arrive at a precipitation figure for open country free from any contaminating influence a gauge had been set down at the left bank at Glasahoe, half-way up Loch Katrine and situated about 35 miles north by east of Glasgow. The results had been somewhat surprising. It was found that the normal monthly precipitation amounts to five tons per square mile. When there was a wind drift in the direction from Glasgow, the figure rose to ten tons per square mile.

The speaker asked Dr. Owens if he could explain the recurring large discrepancy between the use of the smaller standard precipi-

itation gauge fitted with glass collector 12 inches in diameter as against the use of the older gauge having a collector basin 27 inches in diameter when both were placed side by side under identical influences.

Mr. John Roberts recalled an instance where the smoke from a partially-distilled Estonian oil shale had a strikingly beneficial effect on a man who had suffered from gas poisoning in the war.

Dr. S. S. Owens, in reply to Dr. Powell Phillips, dealing with ventilation standards, said his purpose was rather to draw attention to the necessity for a more rational standard than to specify exactly what this should be. The rate of change of air was no measure of the amount required, as the latter must depend to a great extent on the quantity of polluting matter to be removed, that is, it must vary under different conditions. It seemed obvious that since the purpose of ventilation was to provide air which was healthy to breathe, the standard of its purity should be based on the concentration of injurious matter present, which apart from excessive heat, moisture, stagnation or specific injurious dusts such as silica, must, he thought, be regarded as the bacterial contents. His idea was to bring out the need for a new standard in the hope that steps might be initiated in suitable quarters to determine what this should be.

The points raised by Dr. Ashworth on directional deposit were, he thought, answered in his paper. The great difficulty was to insure that one was trapping all the impurities.

Mr. Ashford, of Glasgow, asked for an explanation of what he referred to as the "recurring large discrepancy" between the smaller 12-inch gauge and the old gauge of 27-inch diameter. The answer to this was that he did not think there was any evidence of such a recurring discrepancy when the gauges were correctly exposed.

Chairman: Sir George Newman, G.B.E., K.C.B., M.D., LL.D.,

The Chairman, in the course of his remarks, said that he had always been impressed with the extraordinary backwardness, the almost disgraceful backwardness, of this country in regard to the occurrence of the smoke nuisance and the neglect of its control. We were far more backward than we realized in regard to the matter when compared with our great neighbours across the Channel. The evidence was before all men, and the difference between the district which had a smoke pall and that which had the light of the heavens upon it was unmistakable.

ATMOSPHERIC POLLUTION IN RELATION TO TUBERCULOSIS.

By SIR PENDRILL VARRIER-JONES, M.A. (Cantab.), F.R.C.P. (Lond.)
(Director, Papworth Village Settlement, Cambridge).

At the Memorial Service held in honour of the late Lord Moynihan Blake's "Jerusalem" was sung. Not until then did I realise that those immortal, oft-sung lines contain what is in all probability a reference to the smoke nuisance:—

"And did the countenance Divine
"Shine forth upon our *clouded* hills
"And was Jerusalem builded here
"Among those *dark satanic* mills."

This led me to enquire into the age of the smoke menace; and in a book published in 1914 by Dr. Guy Hinsdale (1) I found a very interesting footnote. It appears that six hundred years King Edward the First was so moved by it that he made the use of "sea-coal" punishable by death. This violent enactment did not last, however, and smoke had again become a notable nuisance in the reign of Queen Elizabeth. The seventeenth century diarist, John Evelyn, (2) described at considerable length the smoke of London in his time; and his contemporary, Charles the Second, did actually adopt what Hinsdale calls "repressive measures" in London. In the early nineteenth century London was colloquially known as "the Smoke"; and in the second year of the present century, Hinsdale states, a singer brought an action against the city of St. Louis, Missouri, and its chief smoke inspector, on the ground that "owing to the additional "presence of smoke, suffocating gases and acid, the health of the complainant was injured."

Like the poor, therefore, and like disease, it appears that smoke has been always with us. Of late years, however, thanks to the efforts of the Smoke Abatement Society and kindred organisations in other countries, scientific thought has been concentrated upon the estimation of the effects of smoke upon the public health, and with greater and greater accuracy we are able to assess its cost.

As if we did not know it already, a popular song not long ago assured us that "Smoke Gets in Your Eyes." If that were all it got into I should not be here to-day; but as it also gets into your lungs I have been asked to speak upon atmospheric pollution in relation to tuberculosis.

With your permission I will deal with this question in three sections. First I will briefly review existing literature upon the subject. Next, I will indicate my conclusions; and then I will submit to you the results of some recent work at Papworth which make my subject far more complex, and many times more important, than it would have been even six months ago.

Smoke and coal dust in the air compels us, willy-nilly, to inhale quantities of tar, oil, and volatile produces of combustion. Of that there is no doubt; but as to the effect thus produced there are several apparently conflicting opinions,

Ascher (3) suggests that the increase of smoke in industrial towns must have some bearing upon the increase in diseases of the upper respiratory tract, because, according to his investigations acute pulmonary diseases are more frequent in industrial towns than they are in the country. This sounds reasonable, since Gautier (4) claims that nine thousand kilograms of H_2SO_3 and HCl descend upon Paris from the air every year. I have not precisely corresponding figures for London; but I am told that ten million pounds worth of coal similarly descends upon London, via our myriad smoky chimneys. When it is remembered that H_2SO_3 destroys chlorophyll even in a dilution of one in a million, and when one considers the effect of air-borne acids upon our public buildings, it would seem strange indeed if the delicate membranes of the respiratory tract should not be affected in an even more serious degree. But does tuberculosis result?

Smoke and Tuberculosis.

The answer appears to be in the negative. Smoke has not, to my knowledge, ever been proved guilty of causing tuberculosis by means of its effect upon the respiratory tract. On the contrary, the experiments on rabbits carried out by Gross (5) indicated that smoke was probably not harmful; and Joetten and Arnoldi (6) who tested the relative irritation of various dusts, found that soot was the least irritating. More important still for us, Dr. Franz Ickert (7) quotes Claissé and Josué, who gave animals soot to inhale and found that no fibrosis developed until tubercle bacille were mixed with the soot.

Other evidence points in the same direction. Dr. Georg Rosenfeld (8) of Breslau, has indeed been led to make a colloidal solution designed to counteract tuberculosis by increasing the coal content of the lung; and Dr. H. G. Obermeyer (9) states that "some authorities have gone so far as to claim that carbon deposits in the lungs offer a kind of immunity against this type of infection." This view is supported by Professor Lyle Cummins (10) who has expressed the opinion that there is a factor in coal mines which tends to neutralize the danger of tuberculosis.

Let us now consider the reaction of coal miners to tuberculosis. These men are exposed to far more coal dust than anyone else; and if it is air-borne coal which causes tuberculosis we shall expect to find among them a very high mortality rate. But this is just what we do not find. Even after ten years' exposure coal miners contract tuberculosis only rarely, *so long as* they are exposed to coal dust alone, and not to a mixture of coal and silica. Böhme (11) found that 1.4% of coal dust in the tissues did not produce any proliferation of connective tissue, whereas as little as 0.7% of SiO_2 is always associated with silicosis in a very severe form. Heymann and Freudenberg (12) find that the incidence of tuberculosis among coal miners is below the average. Only 3.8% of them contract the disease, while 10.3% of stone and ore miners do so. Finally, Arnold (13) after studying the statistics of a whole century, also found that the tuberculosis mortality of coal miners was below the average tuberculosis mortality of the whole population.

What are we to conclude? I think we must admit that the inhalation of smoke arising from the combustion of coal has no causative effect in relation to tuberculosis, but may, and almost certainly does, have a protective effect. Whether that protection is worth having, whether indeed we would not rather be without it, is a matter which I will discuss later. Smoke palls must, with almost equal certainty, favour the spread of the disease. Tonney and de Young (14) say that, in Baltimore, Shrader, Coblenz and others have reported a loss, due largely to smoke, of 50% in solar ultra violet light as determined by actinic methods, and I cannot believe that such a reduction is without effect upon the metabolism generally and the calcium metabolism in particular. The state of calcium deficiency must weaken the resistance to tuberculosis; but this weakening may to some extent be compensated by the mysterious protective factor already mentioned. That fogs resulting from atmospheric pollution accelerate the deaths of tuberculous persons is clear from the evidence of Dr. Veitch Clark (15) and his staff

at Manchester; but weighing all the factors I am of the opinion that we cannot justly and wholly blame smoke for the tuberculosis death-roll.

So far, in using the word tuberculosis I have done so in its hitherto generally accepted sense. I have treated it as though it were a self-contained disease, quite unlike and unrelated to any other. But is this the correct view? Our recent work at the Papworth Laboratory powerfully suggests that it is not; but that, on the contrary, tuberculosis has a very near, and very unpleasant, relation indeed.

Smoke and Cancer.

Before going any further into this, let us now for a moment consider the association between smoke and cancer which has been noted by so many authorities. Here all the evidence seems to point one way, which is so unusual that it must surely be conclusive. Of particular interest is a paper by Dr. Jerome Meyers (16) of the New York Department of Health. He quotes C. E. Green's (17) investigations which show that epithelioma is "very prevalent among chimney sweeps, who show the highest rate for any occupation, "also among gardeners or farmers who use soot," and that "cancer is known to be "frequent among workers in aniline dyes, paraffin, and gas pitch, brewers and metal "workers who use sulphuric acid." Bertillon (18) working geographically discovered the areas in France wherein cancer incidence was greatest; and Green (17), pursuing this clue, found that the highest cancer death rates occurred in the coal-burning areas, and the lowest in the wood-burning areas. Dr. Meyers also refers to the work of Kennaway (19), whose work on the cancer-producing factor in tar is well known, and who concludes his work on cancer produced by gas-works tar, lignite tar and shale oil by saying that "the attempts made as yet to find the cancer-producing substance among the well-known "constituents of coal-tar have given wholly negative results. It is not unlikely that this "substance is a compound, as yet unknown, which is unstable and present in amounts "so small as those of the vitamins in foods; as in the case of some hormones its "identification may be long delayed even when very concentrated preparations may be "obtained."

Dr. Meyers' own conclusions are very interesting. Early in his paper he says that while it is not claimed that smoke accounts for all cases of cancer "it is probably one of "many causes, or one manifestation through biochemical irritation of some great under-lying cause that is as yet beyond our ken"; and at the end, after describing the interesting and illuminating Staten Island experiment, he includes in his summary a reference to a "cancerogenic factor liberated by combustion."

Is that factor, I wonder, linked with the protective factor noted by Lyle Cummins in relation to tuberculosis?

I do not say that it is; I only ask. And I do not ask only out of curiosity, but because an affirmative answer would not be inconsistent with the suggestion, which I am about to submit, that so far from cancer and tuberculosis being two separate diseases there is new evidence to show that they are so very closely related that it is unprofitable any longer to investigate one without reference to the other.

Tuberculosis, Cancer and Zinc.

Some time ago I invited one of our research staff at Papworth, Dr. D. Barron Cruickshank, to investigate tuberculosis from a biological standpoint. He did so; and the result of his study is enshrined in a very remarkable paper which is about to be published by the Sims Woodhead Memorial Laboratory, Papworth, under the title "Tuberculosis, Cancer and Zinc."

The first section of this paper is a survey of existing literature on zinc metabolism. It is a fairly exhaustive survey, traversing a very wide range of research. Reference is made to the facts that coal ash may contain $2\frac{1}{2}\%$ zinc; and there is another point of special relevance to what follows. It is shown how zinc is ingested; and it is also shown that water, milk and other substances corrode, and thereby become to some extent impregnated with, the zinc constituent in galvanized iron. Thus milk, for

example, of which incidentally zinc is an initial constituent, becomes further impregnated with zinc if it be kept for any length of time in a galvanized iron container. I want you to bear that in mind.

In the next section Dr. Cruickshank draws attention to the very considerable decline in chlorosis, better known as anæmia. This decline is admittedly associated with the availability of iron in medicinal form. This association has been observed, and is not now questioned.

Dr. Cruickshank passes on to consider the decline in the tuberculosis mortality, and asks himself whether there is any factor, hitherto unobserved, which may be associated with this decline, in the same way that available iron is associated with the decline in chlorosis. He draws attention to the depressing but inescapable fact that the decline in the tuberculosis mortality began years before sanatorium treatment was instituted; and to the still more humiliating, but equally inescapable, fact that the discovery of Koch's bacillus, and the extensive panoply of treatment based upon that discovery, have not in the least accelerated that decline. Yet the decline is real, and progressive. It must evidently be due to something. It cannot just happen. What, then, is the cause?

It is notable that the rate of decline is associated with the rise in the purchasing power of wages, and the consequently enhanced consumption of foodstuffs, including milk. This is reasonable enough, for we have always held that good food and plenty of milk assisted the mechanism of resistance to tuberculosis. But why should the peak of the tuberculosis mortality—according to Carl Pearson—be reached in 1838? Why not 1708, or 1868? We do not know; no one knows. But Dr. Cruickshank points out that it was in 1837 that Dr. H. W. Cranford obtained a patent for the first galvanized iron container; and that since then galvanized iron has been in increasingly general use. It is not unreasonable, I think, to suggest that galvanized iron may have increased the availability of zinc and this instituted the decline in tuberculosis, in just the same way that the availability of iron has admittedly led to the decline in chlorosis.

Ceasing for the moment to be statistical Dr. Cruickshank then becomes geographical; and he finds that in countries where zinc is present in the soil there is in general high resistance to tuberculosis, but that in areas where zinc is absent resistance to tuberculosis—of the human, as opposed to the bovine type—is low. Becoming botanical, he shows how zinciferous soil influences the synthesis of plants; and then, becoming zoological, he traces the effect of zinc transmitted via the flora and the fauna. Thus he finds that rats, goats and dogs, animals notoriously refractory to tuberculosis infection, all originated in zinciferous districts; whilst peculiarly susceptible animals, such as guinea pigs and apes, derive from territories where no zinc is present in the soil.

Becoming medical, he observes that peoples indigenous to non-zinciferous areas have little nor no resistance to tuberculosis; whereas zinc workers, who are inhaling zinc particles all their working lives, while often afflicted by respiratory diseases such as bronchitis and pneumonia, have higher resistance to tuberculosis than any other class of worker.

Thus, gentlemen, you see that the significance of zinc is considerable. In quantity it is inconsiderable; but it appears to be essential not only to the growth and development of many plants and animals but also to the organization of resistance to tuberculosis. That, too, I ask you to bear in mind.

The Cancer-Tuberculosis Ratio.

Next, Dr. Cruickshank turns to the astonishing fact observed by Dr. Cherry (20) namely that cancer has increased in such an exact ratio to the decline in tuberculosis that the sum of the cancer-tuberculosis mortality has remained constant for more than eighty years. Since 1851 cancer and tuberculosis have together accounted for 20% of the total deaths after the age of 25 each year, accidental deaths excluded. As tuberculosis has fallen, so has cancer increased: the combined toll remaining constant at 20% of the total mortality.

That alone would suggest that there must be some relation between the two diseases: the more especially as there is no such statistical relation between any two other diseases.

Dr. Cruickshank then enquires into the possibility that zinc deficiency may open the door to tuberculosis while zinc excess may lead to cancer. In this connection he notes that it has already been demonstrated that in cancerous tissue the zinc content is relatively high, and that the higher the zinc content the greater the degree of malignancy. Further, that zinc concentrates in the nucleus which controls cell development; so that it may be regarded as either a causative, or a protective, factor. Since, however, the zinc workers, whose resistance to tuberculosis is so marked, suffer a higher cancer mortality rate than any other workers, he is forced to the conclusion that whilst zinc may be a protective against tuberculosis, it may be a causative factor in relation to cancer. In this belief he is sustained by the consideration that the animals from zinciferous areas are resistant to tuberculosis, while animals from non-zinciferous areas are resistant to cancer. Take, for example, the rat, the rabbit and the guinea-pig. In order of susceptibility to tuberculosis the guinea-pig comes first, the rabbit next and the rat last. In order of susceptibility to cancer the exact converse is true. The rat is most susceptible; the rabbit next and the guinea-pig last. Thus the thread of zinc seems to run through, and connect, both diseases.

At this point Dr. Cruickshank seeks to discover the mechanism which will answer a very puzzling question. Since, as Dr. Cherry's statistics show, cancer and tuberculosis are *exactly* antagonistic, the question arises: Can tuberculosis cause cancer if cancer is itself a resistance to tuberculosis?

In search of this mechanism Dr. Cruickshank considered the group of intestinal infections. In these, as you know, the pathogenic bacilli are lysed by the action of non-pathogenic bacteriophages. The condition of the patient depends entirely upon the victory of the one over the other. If the pathogenic bacilli are victorious, the patient dies. If the bacteriophages win, then the bacilli are lysed and the patient recovers.

Hitherto, as Dr. Cruickshank points out, it has been perhaps too readily assumed that all bacteriophages are non-pathogenic. Indeed, it is only recently that research workers have begun to realize that there may be as many species of phage as there are of bacteria. Dr. Cruickshank felt that there was a strong probability that some of these phages might be pathogenic; and he then applied this conception to the question before him. He argued that if the mechanism of defence in tuberculosis could be shown to correspond with the mechanism of defence in the coli diseases, the existence of a phage, probably identical with the lytic factor already demonstrated by Steenken (21), could be presumed; and further that if this phage were *pathogenic*, it could account, as could no other factor, for the exact relation between the cancer-tuberculosis mortality figures.

From this, Dr. Cruickshank has been bold enough to suggest—and in my view to substantiate—the idea that at the moment when the human organism is invaded by the tubercle bacillus this pathogenic phage may come into action, and, by its success or non-success in lysing the tubercle bacillus, decide whether cancer or tuberculosis shall supervene.

It is notable that tuberculosis is the enemy of the young whereas cancer attacks the middle-aged. It is also notable that the zinc content of the tissues, highest in the embryo, falls during early years and rises in later life. Is it too much to suppose that after invading tubercle bacilli have been lysed by the phages, those phages lie dormant until enlivened by the increase in the zinc content of the tissues, an increase specially notable in the nuclei controlling the multiplication of cells?

Cancer has for some time been regarded as a virus disease. The nature of that virus has hitherto been unknown. Dr. Cruickshank has been led, by logical argument based upon admitted premises, to the conclusion that there can be no explanation of the exact relation between the cancer and tuberculosis mortality rates unless the existence of a pathogenic bacteriophage, indigenous to the tubercle bacillus, be admitted. *Is that bacteriophage the virus which all cancer workers are seeking?* In other words, are

Steenken's lytic factor, Cruickshank's pathogenic phage and Gye's (22) non-specific cancer factor one and the same?

That is one question, upon the answer to which may depend great issues. To that I am adding the other question which I asked a few minutes ago, about the possible relation of Meyers' cancerogenic factor with Lyle Cummins' protective factor. All through, you see, there is inescapable evidence that what favours tuberculosis opposes cancer, and vice versa; yet the rigidity with which cancer and tuberculosis continue year after year to claim, in varying proportions, 20% of the total mortality forces upon one the conclusion that the relationship is close and intimate. Can there be any other explanation than that suggested by Dr. Cruickshank? And, if not, can one discuss atmospheric pollution in relation to tuberculosis without discussing at the same time its relation to cancer as well?

It may be that those who are engaged in studying the smoke problem will be able to carry the matter a stage further. Is there any factor in coal-tar which could biochemically aid the multiplication of the phages presumed by Cruickshank? Is there any other product of combustion, either solid or gaseous, which might do so? Something like 85% of us are infected by tubercle bacilli, and amongst that 85% there are three sub-divisions to be noted:—

- | | |
|----------------------------------|-------|
| 1. Those who die of tuberculosis | } 20% |
| 2. " " " " cancer | |
| 3. Those who escape both. | 80% |

Can it be shown that those in the second category have been "smoked" to a greater extent than those in the third? I think it can; I think that it has been shown already, by Bertillon, Green and others.

Remembering that coal ash contains a considerable proportion of zinc (2½%), is it possible that Kennaway's tar-contained compound "unstable and present in amounts so small as those of the vitamins in food" may operate by tipping the symbiotic balance in the direction of cancer? Professor Cook, according to a recent issue of the "Daily Telegraph," stated that he and Kennaway had "arrived at a working hypothesis that 'cancer may be caused by some biochemical process in the body 'taking the wrong 'turning' and creating some product which acts on the cells and forms cancer.'" Can it be that smoke is wholly or partially responsible for upsetting the symbiotic balance and thus activating the pathogenic phages?

These, gentlemen, are all questions which need consideration if the Cruickshank hypothesis be accepted. I must emphasize that it is only a hypothesis as yet. It may be conclusively destroyed. But, if it be upheld, it must surely rank as a contribution of the utmost importance towards the final conquest of the two worst enemies of the human race—tuberculosis, the White Scourge, and cancer, the terror of the civilized world.

1. *Hinsdale Guy*. Atmospheric Air in Relation to Tuberculosis. Smithsonian Institution 1914.
2. *Evelyn, John*. "Fumifugium" 1661.
3. *Ascher*. Über den Einfluss der Rauches auf die Atmungsorgane. Stuttgart 1905 (und Dtche. mediz. Wochstr. 1909 13/14).
4. *Gautier after Dresel*. Lehrbuch der Hygiene Berlin und Wien Urban und Schwarzenberg 1929.
5. *Gross F*. Über die alveolare Reaktion der Lunge gegenueber Russ . . . Beitr. z. pathol. Anat. u. z. Pathol. Bd 76, H.3, S. 374—395. 1927.
6. *Joetten K. W. und W. Arnoldi*. Gewerbe-Staub- und Lungentuberkulose. Berlin Jul. Springer 1927.
7. *Ickert F*. Staublunge und Tuberkulose. Ergebn. ges. Tuberkfrschg. 1931 111 431.
8. *Rosenfeld G*. Kalk und Kohlengehalt der Lungen bei Tuberkulose. Biochem. Zeitsch. 142. 1923.
9. *Obermeyer H. G*. "Stop that Smoke" U.S.A.
10. *Lyle Cummins*. "Silicosis and South Wales Colliers" B.M.J. Mar. 13th, etc., etc. Letter to Editor with *A. F. Sladon*.
11. *Bohme W*. (1) Zur Kenntnis des Röntgenbildes der Lungenanthrakose. Fortschr a d Geb. d Röntgenstr. Bd. 29.
(2) der Verlauf der Staublungerkrankung. Berlin. Springer 1930.

12. *Heymann B. und Freudenberg K.* Die Tuberkulosesterblichkeit der Bergarbeiter im Ruhrgebiet vor, in und nach dem Kriege. Zeitschr. f. Hyg. u. Infektionskrankh Bd. 101, S. 245. 1924; Bd. 104, S. 229. 1925.
 13. *Arnold.* Untersuchungen über Staubinhalation und Staubmetastase. Leipzig. F.C.W. Vogel. 1885.
 14. *Tonney F. O. and De Young C. R.* Smoke Eradication to save the Health Value of Urban Sunshine Am. J. Pub. Health, 1931, xxi 344—354.
 15. *Veitch Clark R.* Report on the Health of the City of Manchester 1933. Smoke and individual Health J. Roy. San. Inst. 1929—30, L. 394—403.
 16. *Meyers J.* Cancer Death Rates, Smoke and Topography. Am. J. Pub. Health Vol. xx No. 6 1930.
 17. *Green C. E.* The Cancer Problem (3rd Edit.) Chicago Med. Book Co. 1914.
 18. *Bertillon J.* Statistique du Cancer d'après des Documents Nouveaux. Presse med. May 13, 1911 p. 385.
 19. *Kennaway E. L.* On the Cancer Producing Factor in Tar. Brit. M. J. Mar. 9, 1924. p. 564.
 20. *Cherry T.* Cancer and acquired resistance to tuberculosis. Med. J. Australia. 1925. 1. 581. Tubercle 1927 8. 283.
 „ Cancer and Tuberculosis viii. A Survey of recent work on the causation of Cancer. Med. J. Australia. 1933 11 p. 197 *ibid.* 1929 1 p. 160.
 21. *Steenken W. Jr.* Lysis of tubercle bacillus in vitro. Proc. Soc. Exp. Biol. N.Y. 1935. 33. 253—55.
 22. *Gye W. E. and Purdy W. J.* The Cause of Cancer 1930.
Gye W. E. Etiology of New Growths. Lancet 18th July. 1925.
 23. *Cook.* Daily Telegraph 29th September 1936.
- Dictionary of Slang 1846: "Country people when going to the Metropolis say they are on way to The Smoke."
- Bullen F. T.* "Cruise of the Cachalot" xxv (1901) 1897. "I desired to know what brought him so far from The Big Smoke."
- Taylor J. S.* Smoke and Health. 1929. National Smoke Abatement Society.
- Ives J. E.* Loss of Light due to Smoke in Baltimore MD. (U.S. Treasury) Public Health Reports Vol. 48. No. 5.
- Chiappe Jean. et Liard A.* L'Action fumivore. Presse. méd. 1929. xxxvii. 1647—1648.
- City Smoke and its Effects: U.S. Treasury Dept. Public Health Reports Vol. 51. No. 1. 1936. 15—18.
- Atmospheric Pollution of American Cities for the Years 1931—1933. (U.S. Treasury Dept.) Public Health Bulletin No. 224.

LIGHT AND CLEAN AIR IN RELATION TO SURGICAL TUBERCULOSIS.

By SIR HENRY GAUVAIN, M.D., M.Ch., F.R.C.S.

Light and Clean Air in Relation to Surgical Tuberculosis.

The objections to a smoke- or dust-contaminated atmosphere are so well known to the members of this Society and are so thoroughly appreciated that it is unnecessary for me to discuss these at length. Rather shall I confine myself to the value of light and clean air in the treatment of surgical tuberculosis.

The effect of local light treatment, so valuable in the various forms of cutaneous tuberculosis, is not here considered. It is a direct effect and entirely different to the remote or indirect effect produced by insolation or the general light-bath.

The sun cure should be regarded as an adjuvant—and merely as an adjuvant—method in the treatment of non-pulmonary tuberculosis. Since its introduction as a routine treatment in the early years of this century much has been written on the subject, and very varying opinions expressed as to its value. On the one hand, some enthusiasts have declared that it is the treatment *par excellence* for surgical tuberculosis, and even alleged that it will cure all forms of surgical tuberculosis, whilst others have been sceptical and doubted of its value. Few who have acquired experience in its practice, doubt that, while it has limitations and cannot in any way be described as a specific treatment, it really represents one of the most important aids to and accelerators of cure which is available. To arrive at a solid estimate of its value it is important to inquire why the results of light treatment in surgical tuberculosis are so variable, why in some case so brilliant, in others so disappointing? If we are able to answer this question we shall be in a better position to conduct sun treatment with assured success.

Where Sun Treatment Fails.

Let us first consider where sun treatment fails. It certainly will not prevent infection. Persons living under ideal conditions for the practice of heliotherapy and indeed who are undergoing insolation, may be infected readily and the disease may progress rapidly and end in death. For example, unimmunized natives of equatorial islands exposed constantly to sun and ultra-violet light of high actinic value are notoriously susceptible to tuberculous infection.

It should be noted that though there is abundant sunshine within the tropic its therapeutic value, described by some as its quality, is inferior to that in many temperate climates. I am able to confirm this statement by personal experiment. Moreover, in some countries where light of high actinic value is available, producing rapid initial pigmentation, exposure over prolonged periods of time may result in the reverse and de-pigmentation may occur. Pigmentation will again take place on removal of the subject to a different locality even if light of lower actinic value only is available.

Tuberculosis may develop at a sun-cure station in the Alps and proceed to a fatal termination. Bernhard, though extolling the value of the sun in the high mountains, quotes Sauerbruch, who draws attention to "The remarkable observation that swollen tuberculous glands in children who live in the high mountains will not heal up in spite of sun and direct radiation, but rapidly improve at sea-level or in brine baths in the plains."

When searching the literature one cannot but be struck by the fact that explanations put forward as to how sunlight or ultra-violet light from artificial sources acts, so often lack conviction or substantial authority. The clinician, proficient in its use, accepts its benefits without giving an adequate explanation. The physicist seems most concerned in ascertaining the wavelength and intensity of the rays employed, while the physiologist seeks specific effects such as the influence of skin pigmentation, thermal effects on the blood (Sonne's classical experiments), changes in haemo-bactericidal power, alterations in the composition and chemistry of the blood, effects on calcium metabolism, vitamin productions, etc. No single one of these phenomena afford a

complete explanation of the value or danger of heliotherapy. It is desirable to consider the subject on broader lines and not be unduly diverted by certain known sequelæ to insolation to the exclusion of the combined final clinical result.

Efficacy of Changing Conditions.

A person undergoing insolation in this country is absorbing light energy under conditions which imply seasonal and, indeed, daily and hourly variations. The intensity and character of the solar radiation varies with the angle of incidence of the sun's rays, the purity of the atmosphere through which they are projected, latitude, altitude, climate, temperature, effect of surroundings promoting or impeding secondary radiation, and, indeed, a host of factors which may not be neglected. The one common unchanging factor is that of constantly changing conditions.

The point of interest to observe is that under these changing conditions, provided that they are not too extreme, light treatment is most efficacious. It is a matter of extreme importance to realize that always provided there is a reasonable amount of sunlight available, heliotherapy, for its general effects in surgical tuberculosis is more effective in the constantly changing conditions, not merely solar, found in temperate climates, than in the comparatively stable conditions found in many tropical countries, where there may be greater actinic intensity, but not such diverse variations. By experiments personally conducted, I am of opinion that even in the Arctic Circle there are occasions when insolation there is of greater value than on the Mediterranean coast or in the high Alps.

There is, however, one factor of extreme importance which we may largely command and which is of especial interest to this Society. The transmission of ultra-violet light, the all-important therapeutic constituent in the solar spectrum, depends very largely on the state of the atmosphere, and the value of clean air with absence of smoke or mist cannot be too strongly emphasized. A pall of smoke acts as a most efficient barrier to the passage of ultra-violet light and it behoves us to abolish this screen wherever possible.

Variation of Individual Response.

Having noted the significance of alterations in the intensity and character of sunlight on the individual subject treated, it is of interest to consider the power of response to the light stimulus of the irradiated subject. Individual response shows extreme variations. This is true whether the source of light is solar or produced from artificial sources. In the latter case, however, while individuals vary, the light applied and the other factors remain approximately constant. If half a dozen different patients are exposed to a similar source of radiation, sun or artificial light, or to a combination of both, the sum total of the individual results will be found to vary within wide limits, as shown both by the appearance of the patient and the rate of progress towards recovery. Moreover, it is not possible by altering the exposure to which individual patients are subjected, to attain the same improvement in all, or to equal the greatest improvement made by the patient with optimum response. The power of total response varies widely and recognition of this fact is of extreme importance in estimating the value and prescribing the dosage of light applied.

It may be important to know the intensity of the light utilized in the different regions of the spectrum, and the significance of the individual biological responses elicited, but there is no evidence that the sum of the biological responses evoked will be similar in each individual irradiated by identical light, under precisely similar conditions. Indeed, all clinical evidence with which I am acquainted in surgical tuberculosis would lead to a contrary view. Viewed clinically, the different responses in different individuals seem almost infinitely variable, and one is forced to the conclusion that a correct clinical estimate of the total effect produced is of greater value in treatment than precise information as to certain reactions. In the present state of

our knowledge heliotherapy is an art rather than exact science. Consideration of these facts has led me to formulate what may be called the "theory of varying stimuli and varying response" in light treatment, and may afford a reasonable explanation of the successes and failures we meet. It also constitutes a working hypothesis as a guide to treatment. The more one considers the alleged superiority of sunlight to artificial light rich in ultra-violet rays, in the treatment of the subject attacked by surgical tuberculosis, the greater becomes the feeling that this superiority is due not so much to the intensity as to the variations in quality and intensity of light, assisted by changing external factors not directly due to light.

Variations due to Age and Health.

It is important to bear in mind that while there are great individual variations in response to the light stimulus, individuals themselves vary enormously at different periods of their lives, according to the state of their health and even at different periods of the day, and at different seasons of the year. Healthy infants usually react well, but at first, at any rate, require only comparatively short exposures. Strong adolescents and adults can, as a rule, tolerate and benefit by considerable exposures, but as age advances smaller and smaller doses are essential, because the effort needed to obtain a reaction exhausts the enfeebled patient. That does not mean that an elderly patient is unsuited for light treatment, but it does mean that the length and intensity of the exposure should be so regulated that he is capable of reacting satisfactorily without exhaustion or distress to the dose applied. Similarly with sick people, the utmost caution should be observed. In acute disease with pyrexia, light treatment is generally contra-indicated, and in those so enfeebled that their resources should be conserved, light treatment should not be given.

Light treatment must be regarded as a tonic treatment, a shock treatment, and should be reserved for those who are capable of responding, and exposures graduated according to the response each individual is capable of usefully making. As with other tonics, continuous administration is not associated with progressive response, even when the dose is increased, and excessive or prolonged exposure to light is not only not beneficial, but sometimes definitely harmful and may be dangerous.

As a general rule, red-haired persons, and subjects who freckle, do not respond nearly as well as those who pigment well, and, in the former, short and cautious exposure should be the invariable rule. Cachectic people with muddy complexions, lethargic and myxoedematous types also do not respond well, and infinite care is needed with these. For these also treatment is to be preferred at inland stations, and not at the seaside, or in the mountains where the stimulus is likely to be excessive, and beyond the subject's power of response.

It is a common fallacy to imagine that when sun treatment is indicated the patient should be sent to a very sunny locality where there is intense and continuous sunshine of high actinic value. For very strong, dark adults capable of responding to intense exposure this is commendable, but to the majority of sick people initial weak stimuli are to be preferred. There are few countries where sun treatment may be practised under more ideal conditions than in the spring and summer in the south of England where abundant sunshine for therapeutic purposes is available, sometimes largely in excess of the patient's needs.

How Sunlight Acts.

Confining myself to the general effects following insolation, I may perhaps best describe the therapeutic action of sunlight under two headings: (1) its direct or local effect; (2) its indirect or remote action.

The first may easily be explained. Sunlight has a powerful direct bactericidal action; it has been described as the world's greatest antiseptic. This bactericidal property is exercised by the ultra-violet rays in the sunlight. Owing to their very limited penetrating power, this action is strictly limited. These lethal rays will not even

penetrate the skin, but unprotected organisms lying on the surface of superficial wounds are rapidly killed by the direct action of light. In blanched, anæmic tissues the penetrative action of ultra-violet light is increased, and this fact is utilized in the treatment of lupus initiated by Finsen, where the lesion attacked is rendered anæmic, and an intense source of ultra-violet radiation employed. The lethal effect of the light is increased by a helpful, intense inflammatory reaction, which properly controlled exposure elicits. In this way lupus, that disfiguring manifestation of tuberculosis, may, if not too deep seated, be successfully treated.

Indirect Action of Sunlight.

The indirect or remote action of sunlight presents the most fascinating problem for the consideration of the heliotherapeutist. I purposely exclude from our present consideration narrow specific reactions, as I desire to aid especially the person who is a sun-worshipper, and wishes to obtain the general benefits of sunlight to which he exposes his body. A reddening first appears on the skin, the so-called "erythema solare," about six hours after suitable exposure. After insolation has been repeated a few times a pigment, melanin, is gradually deposited in the skin, which becomes brown and later bronze. As the skin becomes more and more pigmented, so the person insolated becomes protected against the harmful effects of ultra-violet light, and is able to withstand increasingly long exposures. Simultaneously the beneficial remote or indirect effects of sunbathing appear. How they appear is a controversial matter and I shall not attempt to deal with this aspect of the subject; I shall adopt Vignard's picturesque simile: "The skin becomes a vast keyboard on which the light strikes, awakening deep resonances throughout the body." The most concise and at the same time the most admirable description of the remote or indirect action of sunlight with which I am acquainted was written by a layman, Norman Davey: "The sun is a dispeller of ill humours. He is the Healer, the Lifegiver. He is the only true Doctor to the troubled mind. He is the best Apothecary in the world. There is no tonic sold for gold, over any chemist's counter, so remedial as that celestial pick-me-up, which is poured for nothing each morning over that wide counter which is the rim of the earth."

Stimulation.

Now briefly, what are these remote effects, these deep resonances awakened throughout the body? They are powerful, stimulating, tonic effects produced on both mind and body. Sunlight exhilarates and enlivens. It induces gaiety, liveliness, and a sense of well-being. It braces up and cheers the soul. Like all stimulants, if pressed to excess it intoxicates and then exhausts; again like all stimulants, if exhibited over too long a period, its tonic action decreases. That is why the fortunate resident in a temperate climate derives greater benefit by fitful and occasional indulgence than the dweller in the tropics, on whom its tonic effect ceases. The tropical native tends to become immune; the European immigrant, at first exhilarated, later tends to become irritable and exhausted, and not infrequently feels he needs other tonics to assist him. The very ill person will invariably prefer to remain in a darkened room. He is unable to respond to the light stimulus and his small store of energy should be conserved and increased, but not uselessly dissipated.

Effect on Mental Capacity.

Not only is the vivacity of the person submitted to properly planned sunbathing increased, but his mental capacity is raised, his resistance to infection increased, and his power of recovery from illness accentuated. Thus it is that our little "children of the sun" at Alton and at Hayling Island are helped in their battle against the tubercle bacillus which has attacked them. In an investigation on a large number of physically defective children being treated in towns and at Alton and at Hayling Island, Dr. McCrae and I were able to show that the average mental intelligence of the hospital child receiving systematic light treatment was 10 per cent. greater than that of a similar

child not receiving such treatment. This observation should surely have an important bearing on the education of children and should be taken to heart by parents and the teaching profession. Parents especially might use the summer holiday for their children with great advantage if they realised its possibilities. A month or six weeks in each summer devoted to open-air life, with rational sun exposures, would be rewarded by an improvement in mental and bodily activity. It would increase the child's immediate and ultimate potentialities and prospects to an extent which would more than repay any trouble or expense involved.

Time does not permit me to enlarge in greater detail on the effects of sunlight on the body and in the amelioration and cure of disease. I hope, however, that I have said enough to awaken you to the value of a method of treatment capable of general application and free to all.

Cold Air Treatment.

For the explanation of the effect of cold air on the nude subject we are largely indebted to Sir Leonard Hill and Dr. Argyll Campbell's researches. The air bath necessarily is synchronus with the sunbath. Some of the effects of the former had been ascribed to the latter. Actually, exposure to cold air results in loss of heat from the body which if reasonably controlled may be beneficial to the patient. Additional heat has to be generated to replace heat lost and so work has to be done. This necessitates the ingestion, digestion and absorption of more food and increased respiratory activity with more oxygenation of the tissues and increased elimination of CO_2 . There follows increased tissue change and associated repair in diseased tissues. In this way controlled exposure to cold air is beneficial to the patient and exposure to clean air facilitates heliotherapy.

THE OBSTRUCTION OF LIGHT BY SMOKE AND ITS EFFECT ON HEALTH.

By SIR LEONARD HILL, M.B., F.R.S., LL.D., Hon.A.R.I.B.A.

It is an astonishing fact that owing to the small solid angle subtended by the earth at the sun as centre, it receives only $1/500,000,00$ of the sun's total output of radiant energy, yet this amount may be enough to make rocky surfaces too hot to touch in the tropics. The actual amount of energy received is equal to about one calorie per sq. cm. per minute, but this amount in cities is enormously reduced by the smoke pollution of the atmosphere. We lose the genial warmth and light of the sun by our dirty habits; the sun, energizer of all life, which has been worshipped as a god by generations of men. The sun is the source of a continuous spectrum which stretches over a very wide range of wave-lengths, but is very greatly modified before it reaches us. The outer and cooler parts of the sun absorb certain wave-lengths and produce the dark lines seen in the spectrum. The earth's atmosphere in its turn limits the spectrum by its absorptive power. Beyond the red end of the spectrum lies the invisible infra-red, or dark heat rays, and beyond the violet end the invisible, but chemically active, ultra-violet rays. The range of wave-lengths extends between 3.0μ ($\mu = 1/1000$ mm.) in the infra-red and 0.3μ in the ultra-violet. The maximal energy of the sun is in the green, where the wave-length is 0.47μ . In this respect the sun is different from artificial sources, the maximal energy of all such, owing to their lower temperature, being in the infra-red.

The electric waves used in Radio, heat, light, ultra-violet, and X-rays are all manifestations of the same general phenomenon. The essential difference between them being that of frequency of vibration, or wave-length. The very short wave-length of the sun's spectrum are absorbed in a region of the atmosphere some 30 miles high by a very thin layer of ozone, which is formed through their absorption by, and action on, the oxygen of the air. In consequence the sun's spectrum scarcely extends beyond the wave-length 0.30μ , while that of artificial sources such as arc lamps, extends to about 0.20μ . The still shorter rays given off by arcs absorbed by the oxygen of the air give rise to ozone. The ozone layer in the atmosphere some 30 miles high varies, and with its variation there varies the ultra-violet rays which reach the earth. The strength of sun treatment on clear days may then vary with this ozone layer. It is by variation of the ultra-violet spectrum that the ozone layer is studied and its depth measured.

Ultra-Violet Rays.

It is the ultra-violet rays, and the shortest wave-lengths of these, which cause sun-burning, and are of great importance to health. At the surface of the earth with the sun moderately high in the heavens, the percentage of ultra-violet varies between 1 and 5 per cent. of the total energy, the visible between 41 and 45, and the infra-red between 52 and 60. Who would think standing in the glorious midday sun that a greater part of the rays were invisible? In the case of artificial sources the infra-red rays form a much higher percentage of the whole energy. Less than 10 per cent. of the energy of an incandescent lamp is utilized as visible rays compared with the sun. A greater amount, as well as shorter wave-lengths, of ultra-violet are to be had from arcs, such as the mercury vapour lamp, because they are not weakened by absorption due to the atmosphere.

As the sun sinks in the sky the ultra-violet decreases in amount. There is then far less risk of sun-burn in the early morning or late afternoon than about midday. Observation shows that matter emits or absorbs radiation, only in definite quanta of energy. The size of these quanta is related to the frequency of vibration, the quantum being larger the shorter the wave-length. For rays to have effect on, they must be absorbed by, a material. The short ultra-violet rays produce a powerful action on living cells because of their complete absorption by a very thin layer of living substance, and their high energy content. Thus the cornea, while letting through visible rays, absorbs the shortest rays of sunlight, and these provoke conjunctivitis and sun-blindness. Hence

the need for sun spectacles, particularly on snowfields, which reflect the ultra-violet rays on the eyes, and when facing arc lamps. In the upright posture the eyes are protected from the sun by the eyebrows and eyelashes. It is most important that babies should not be exposed to the sun when lying face upwards in perambulators.

Clouds, haze, and smoke pollution by absorption decrease the energy of the direct sun enormously, and screen off all the short ultra-violet rays. With the sun low in the heavens as in winter even on a clear day the shortest wave length may be 0.315μ , and this has little effect on living cells. Rain and snow purify the atmosphere by carrying down dust and so lessen the absorption and scattering of the sun rays. It is in bright intervals between squalls when the sun is high in the sky, that the highest ultra-violet readings are obtained, *e.g.*, by means of the acetone-blue gauge. To make these readings a standard solution of acetone blue is exposed for a given time in a quartz tube and in a glass tube, each of standard size, and the amount of fading of the solution in each tube then measured by comparing it with a set of standard tubes of varying depth of colour. The fading of the solution in the glass tube is deducted from that of the quartz tube, and the result gives the amount of short ultra-violet rays in terms of biological action. One unit on the scale being twice the amount required to produce a slight degree of sunburn on the average white arm. Quartz is transmissible by the short ultra-violet rays, while glass is not. By deducting the glass tube reading from the quartz one the slight action of visible rays on the acetone blue solution is made of no account. Readings with the gauge are made in many towns, and some are reported daily in the "Times."

Owing to the reflecting power of the snow fields, and the clear sunny atmosphere, high Swiss health resorts offer excellent conditions for sun treatment in winter. Moreover, the air there is dry and cold, while there is little wind, and conditions are most favourable not only for exposing the skin to the sun, but for the respiratory membrane. Cold dry air greatly enhances the evaporation from, and circulation of blood through, the respiratory membrane. The power of the membrane to resist infection is thus enhanced. At the same time exposure of the skin to sun-light increases the disease resisting powers of the body. Our smoke polluted cities give us the very opposite of these ideal conditions. The fog takes away the sun-light and the blackened walls reflect little of what there is.

The air indoors is warm, and holding much more moisture takes up less from the respiratory membrane. White plaster has a high reflectory power for all the rays of the sun; hence the utility of a white wall for sun treatment. In winter it gives protection from wind and increases the sun's power. Sand has a very high reflective power for infra-red rays and contributes to the heat of deserts. Snow and green fields have a small reflective power for these rays. Water vapour begins to absorb the infra-red rays beyond 1.0μ , so the sun's spectrum does not extend beyond 3.0μ . The outgoing radiation of the sun-warmed earth lies between 4.0μ and 50μ , with a maximum at 9.5μ . Water vapour absorbs this radiation, hence the close effect of a still cloudy night compared with the clear sky, when the earth radiates its heat away into cold space.

Much of the ultra-violet rays comes from the blue sky or white clouds as scattered and reflected rays. In fact, more comes from the whole sky than from the direct sun when this is below an angle of 45° . The whole area of the sky down to the horizon is 92,000 times that of the sun. Ultra-violet ray treatment can then be had from sky shine, when the hot direct sun of midday is screened. The total short ultra-violet rays falling on the earth is some 15 times greater in summer than in winter.

Clothes, walls, and glass windows cut the skin off from the natural stimulus of sun-light. It is the fibres of a loosely woven garment which screen off the rays, while the spaces let them through, and make a sun-burn pattern on the skin. The best protection against the sun is a closely woven white fabric such as an Arab wears. Aluminium foil is useful for insulating huts from the sun in the tropics. Special glass has been introduced which allows the short ultra-violet rays to pass, but a child would have to

sit all day in a room provided with a north window of this glass to get as much short ultra-violet rays as he would in two minutes out of doors in the midday sun.

Sun-burn.

Sun-burn is the result of rays of 0.3μ acting on the layer of living cells which lie just beneath the horny layer of the epidermis. As these rays have very little penetrating power very little of them reaches the most superficial capillaries in the derma. By damaging the living cells of the epidermis they excite an inflammatory reaction which is not immediate but comes on some hours after exposure. The products of the damaged cells excite flushing of the blood vessels in the derma and exudation of fluid. If the damage of the cells is considerable there may be blistering, but, be it noted, owing to the fact that the rays cannot penetrate deeply the damage of a sun-burn is only superficial. There follow afterwards peeling of the skin and pigmentation, or browning. The action of the sun on the skin stimulates the whole body and (if not excessive) tones it up. Severe sun-burn over a large area, carelessly produced by prolonged exposure of the white skin to the high sun on the sea shore may make the victim very uncomfortable and feverish for some days, but there is no risk of life in the case of the strong and healthy. For those suffering from tuberculosis of the lungs such over-exposure is bad, and moderation is the wise course until the skin is browned and become immune to sun-burn.

Immunity comes about through thickening of the horny layer of the epidermis as well as through pigmentation of the living cells which lie beneath. The pigment in particular protects the subjacent blood from being over-exposed to, and overheated by, the visible rays. The absorbed rays converted into heat excite nerve endings in the epidermis, which in their turn excite the sweat glands, and the co-operation of sweat carries away the heat. Owing to pigment a negro can have a thinner skin than a white, and thus lose heat more easily from shaded parts of his body. The transmission of red rays through the cheek of a white man is made visible by putting a glow lamp in the mouth and standing in front of a mirror in a dark room. No red rays come through the cheek of a negro.

The visible and short infra-red rays penetrate the epidermis to a significant amount in the derma, the red and short infra-red are not absorbed therein but penetrate still deeper. The longer infra-red rays on the other hand are absorbed in the surface layer of the epidermis and heat that in place of the deeper tissues. The penetrating rays excite transpiration of moisture and flushing, and by evaporation and by the circulating blood the absorbed heat is carried away. A higher energy of penetrating rays, therefore, is endurable than of the longer infra-red rays, and their radiation has a pleasanter quality. The longer infra-red rays from dull red and dark sources of heat by heating the surface give a feeling to the skin of dryness and tightness. The temperature beneath the skin may be raised to 115° F. by the penetrating rays when the just bearable amount is reached, while with the longer infra-red rays the endurable temperature is only 107° F. This is because the latter heat the surface more and quickly raise the epidermis and its nerves to the unbearable point.

With the longer infra-red rays the gradient of skin temperature is from without inwards and the temperature quickly rises to fall again when the irradiation is over. For the short infra-red and visible rays the gradient is from within outwards, and the temperature under the skin drops slowly after irradiation. The heating of the blood and deeper tissues is an important part of sun-treatment.

The Curative Action of Sunlight.

The sun has a wonderful curative effect on wounds; the infra-red, visible, and ultra-violet rays all take part in the healing effect. More blood and lymph is brought to the skin, and the living cells of the epidermis stimulated to effect repair. Pain is taken away, excessive moisture dried up, and microbic infection checked. The white corpuscles under the stimulus of sun-light come to the wound in increased numbers,

and battle with the microbes. Sun and open-air treatment favour drainage, which is impeded by dressings, and keeps down the absorption of toxic wound products and fever. Microbes are favoured by warmth and darkness under dressings. The cost of sun-light and open air is nil compared with that of these. Since 1902 the famous Swiss surgeon Bernhardt of Davos has proved all these things. By the use of artificial sun-light results similar to his can be obtained in this country where mist and smoke pollution cut out much of the sun-light, but few surgeons follow in his steps. The dose of sun-light must be a mild one first, sufficient to provoke flushing of the normal skin. For lacerations, cellulitis and burns sun treatment is excellent. So too for treatment of certain skin diseases such as eczema, psoriasis, alopecia areata, erysipelas. Boils and carbuncles in the incipient stage may be made to subside by strong doses of artificial sun-light. As a counter-irritant strong and even blistering doses of ultra-violet rays are most useful in treatment of asthma, sciatica, and other forms of neuritis. For corneal ulcers, sty, conjunctivitis, etc., light treatment in the hands of experts is most useful.

For all forms of surgical tuberculosis sunlight and open air are of the greatest value. Given carefully sunlight with cool conditions is good for tuberculosis of the lungs. Sunlight treatment must not be given in glass houses or hot shelters. Out of doors on the snowfields of Switzerland there are ideal conditions. For the dreadful lupus (tuberculosis of the skin) strong doses of ultra-violet rays are needed at the seat of the disease. For tuberculosis of the larynx a small water-cooled mercury vapour lamp, which can be introduced into the mouth, is most useful. For rickets sunlight is the curative agent. There is an antirachitic vitamin which is made out of a certain part of the fat of the skin by the action of the short ultra-violet rays. This vitamin D (as it is called) is necessary for the proper growth of bones and general health of the body. Given proper food, and exposure to the sun and air, babies will never suffer from rickets, with all its attendant catarrhal troubles and lessened resistance to infectious fevers and their sequelae. Ill-nourished and weakly children are made strong under sunlight and open air treatment. Dullness, apathy, irritability, sleeplessness, tendency to catarrh, are replaced by liveliness, good appetite, restful sleep, and lessened liability to colds. "Artificial sun-light clinics are bright spots in city life," says Dr. Morton of the Stratford (E) Day Nursery. Joy in living is the result of the open air school, and weight curves which run off the official charts.

Sun-light influences breeding. Birds and rodents breed when the light begins to grow stronger after winter. The higher monkeys only breed in this country when given artificial sunlight. Esquimaux women cease to menstruate during the dark winter months. Apart from the use of anti-natal methods the very darkness of city tenements depresses breeding power. The birth rate is dropping so fast that before long the nation will largely become one of old people, and national decay must result.

The Action of Dark Heat Rays.

My recent research work has shown that the air tubes of the lung are narrowed reflexly by way of the nerves when the skin is irradiated with dull red or dark sources of heat. The effect is set aside by cooling the skin by means of a fan, and in many people, also, by rays from a bright source of heat. Stuffy feelings in rooms are popularly ascribed to chemical impurity of the air, *e.g.* to deficient oxygen, or excess of carbon dioxide. In the most crowded stuffy room, however, the air is not chemically altered to any extent which will have a physiological effect. It is the quality of the heat rays acting on the skin and air tubes which produce the stuffy feelings. All sources of dull red and dark heat should have their stuffy effect set aside by adequate ventilation of rooms with cool air. Such ventilation will at the same time sweep away infecting microbes which are sprayed into the air by "carriers" when sneezing, coughing, or explosively speaking. The discovery that certain infra-red rays reflexly congest and narrow the airways of the lungs is, I think, one of great significance. The effect can be demonstrated by first closing the nose with a clip or by pledgetes of wool, and then breathing in and out through a tube held tightly between the lips, and making the orifice

of this tube so small that breathing is somewhat difficult. Then approximation to a dull red electric heater will make the breathing more difficult, while the turning on of a fan will make it easier. People vary in their sensitivity to stuffy sources of heat, and in their desire for cool open air. The natural conditions out of doors are ideal on a sunny day with a cooling breeze. Glass houses screen off the cool air and the rays which keep the air tubes of the lungs open, and leave in action those which narrow the air ways and produce unpleasant feelings. Hence the stuffiness felt on passing from outdoors into a glass house. The influence of open air and sunshine on the air tubes is part of the good effect of open air treatment.

To all the good effects of sunlight which I have mentioned, health and joy giving, anti-rachitic and anti-tubercular powers, power to heal wounds and skin troubles, etc., I must add the growth of green plants which give us essentials for our growth, either directly or by way of the cow as milk products. It is all these which are cut off by smoke pollution.

Smoke pollution makes towns hideous and dirty, destroys gardens and parks, corrodes metals and buildings, enormously increases the task and cost of washing and cleaning, impedes transport and so interrupts work, trade, and pleasure, increases the cost of artificial lighting, and by making the surroundings squalid depresses the mind.

We have got pure water and good drainage, clean streets and courts, now we must clean the air. It is far less costly to prevent than to cure disease.

JOINT DISCUSSION

Mr. T. E. Birtwisle, M.B.E. (Castleford), representing the Sanitary Inspector's Association, said he would like to speak a word of appreciation of what they had heard and seen that morning. It had been a veritable feast of good things and he hoped they would not suffer from intellectual indigestion.

Sir Leonard Hill, who was to a number of them present a very beloved Gamaliel, at whose feet they had sat for many years, had made reference to the disadvantages attending the use of dark sources of heat. He would like to ask Sir Leonard, whether he would look with disfavour on the use of open coke fires with their dark red glow, and the dark coloured panel heaters so often used in public buildings.

The dancing yellow flame of the coal fire and the brightness of the "high beam" radiant of the gas fire were a source of pleasure in themselves, and from the psychological aspect alone appeared to have much to recommend them.

Dr. H. Osborne (Salford) said that the town he represented was situated in South-East Lancashire, and was very heavily polluted with industrial smoke, which made an acid atmosphere which was one of the worst in the country.

As the Medical Officer of Health he had made many investigations, as a result of which he had found that the chief cause of mortality was bronchitis of the lungs, which was due very largely to atmospheric pollution.

He compared the death rate due to bronchitis of Wallasey with that of Salford, and

said that the Wallasey death-rate was one-third of that of Salford. He was certain that bronchitis of the lungs was caused by atmospheric pollution, and the fact that cancer of the lungs was more prevalent in towns and cities than in seaside places might also be attributed to this factor.

Dr. J. Johnstone Jervis (Leeds) referred to the influence of atmospheric pollution on diseases, as mentioned by Sir Pendrill Varrier-Jones. He said smoke was quite a different thing from coal dust. Smoke was a direct product of coal combustion, for it sent out sulphuric acid, which caused the greatest trouble. It was this acid which made fog cause so much damage in an industrial city.

He would like to ask Sir Henry Gauvain whether it was just the effect of light and treatment at his hospitals which healed their diseases, or whether it was due to the good food, clean surroundings, etc. He wondered whether it was worth while sending children from the slums for treatment at hospitals, when they had to return to the dirt and grime of city slums again.

He would like to know whether the smoke in the atmosphere of the cities allowed the ultra-violet rays of the sun to penetrate and enter the homes, and so could it be worth while having the windows open.

Alderman D. P. Charlesworth (Wallasey) referred to the statement made by Dr. Osborne, when he compared the atmospheres

of Wallasey and Salford. He would like to point out that Wallasey was not as clean as it would be if it were not so close to Liverpool. Wallasey suffered from the smoke and noxious fumes of Liverpool. A large amount of the smoke Wallasey received was from the steam engines in the centre of Liverpool.

Alderman W. Muirhead defended Liverpool, and said that the people of Wallasey, who came each day into Liverpool, helped to contribute to the smoke nuisance.

Councillor C. E. Keene (Leicester) asked Sir Pendrill Varrier-Jones whether the man inhaling cigarette smoke suffered any effects.

He said the health side of the organization was not being sufficiently stressed. If progress was to be made they must show to the public the effects of smoke upon their health. Now was an opportune moment to get on with this job.

Mr. Charles Gandy (Chairman of Executive) proposed a vote of thanks to the three speakers and the Chairman, which was carried with acclamation.

Sir Pendrill Varrier-Jones, in reply to Councillor Keen, said that there did not appear to be any definitely scientific evidence which pointed to the fact that the inhalation of cigarette smoke was harmful to the lungs, yet at the same time cigarette smoke contained much more carbon monoxide than pipe smoke, and could not fail to have a detrimental effect.

There was definite evidence that the practice of inhaling cigarette smoke was more than twice as common among men who suffered

from duodenal ulcer than among normal men, and that it was definitely harmful to such sufferers. It was not established that inhalation was a cause of chronic duodenal ulcer, but there was no doubt that it was an important factor. Whether the ill-effects were caused by the nicotine or the carbon monoxide it was impossible to say at present.

Sir Henry Gauvain, replying to the discussion, said that Dr. Johnstone Jervis' question could be answered in the affirmative. He was in the position of having two classes of patients to treat, the hospital class, some members of which came from the slums, where they lived in unhygienic conditions and sometimes suffered from malnutrition, and he also had a large Clinic at Morland Hall, Alton, where private patients arrived from good homes. These had lived under the best hygienic conditions with ample food of good quality. Both suffered from a similar disease but came from totally different environmental conditions. Nevertheless, both progressed towards recovery in a precisely similar way. It was, therefore, reasonable to state that the improvement effected was due to the light and other treatment and could not be simply due to good food, clean surroundings, etc. The children returning to the dirt and grime of city slums had undoubtedly benefited and were fortified for the further fight they had to make under the grim conditions in which they existed.

Sir Leonard Hill, in reply to Mr. Birtwisle's question, said that any stuffy effect of dull red or dark heat could be set aside by ventilation with cool air.

Sixth Session, Friday, 16th October, 2-30 p.m.**Chairman: Professor Sir John Robertson, C.M.G., O.B.E., M.D., B.Sc.****PUBLIC HEALTH ADMINISTRATION AND SMOKE ABATEMENT.****DR. A. S. M. MACGREGOR, Medical Officer of Health, Glasgow.**

The promotion of the health and amenity of our cities and towns demands that everything possible should be done to secure a cleaner atmosphere, freer from the industrial and domestic smoke which deprives communities of their proper proportion of available sunlight. Although the precise effect of smoke pollution on health is difficult to demonstrate scientifically, I think it can be affirmed that the attainment of a full measure of health is prevented and that life under a canopy of smoke and its associated chemicals is one of subnormal health. An unnecessary burden is certainly added to domestic cleanliness. Again, it is well known that smoke fogs cause direct injury to health. Winter fogs in a northern industrial city, especially when they are associated with low temperatures, increase the incidence and mortality of the respiratory diseases, sometimes to a high degree and with consequences which may be prolonged well beyond the actual period of the fog itself. The abatement of smoke, therefore, demands careful attention in the interests of health; notwithstanding that some progress has been made, continues to be one of the major environment services in the towns of this country. Purification of the air is not an exact science, and there are many practical difficulties of a technical and financial as well as of an administrative kind to be overcome before unclean air as a contributory cause of sickness and ill-health is finally eliminated.

The particular aspect of prevention which I am asked to discuss is the administrative side of smoke abatement—the measures available to local health authorities, the results obtained, and the issues that remain. In doing so, I shall have to draw largely on my own experience, as this is a problem which varies from district to district; there is also a considerable difference between Scottish and English legislation for the control of industrial smoke.

Functions of Local Health Authorities.

In their efforts to reduce the smoke nuisance, local health authorities engage, or can engage, in a number of activities which may be summarized as follows: (1) administration of the law for the control of industrial smoke emission; (2) observing the amount and nature of smoke pollution in the area; (3) surveying and noting the technical changes which take place in the construction of plant for power purposes, and assisting those changes which are salutary; (4) organization of courses of instruction in boiler-house practice and furnace management and in the use of suitable fuels for specific purposes; (5) undertaking or assisting investigation and research into problems relating to atmospheric pollution and the abatement of the smoke nuisance, and also in fuel technology; (6) public education.

These functions cover much ground but all are essential items in local administration. It may be remarked that no public health service is more dependent for its effectiveness on the goodwill and co-operation of the public and of the various industrial and other interests involved. This is particularly so where intimate contact is made from day to day with furnace users, and where the administration lays stress on advisory functions as regards the right use of fuel and the right fuel to use.

Administration of the Law relating to Smoke.

The adequacy of the statutory powers possessed by local authorities for the abatement of smoke has been much criticized. In England there is a general Act, the Public Health (Smoke Abatement) Act, 1926, by which at least uniformity of local administration may be ensured. Scotland is in much the same position as England was prior to the passing of the Act of 1926, i.e., dependent for general powers on the Public Health (Scotland) Act, 1897, and on the earlier Smoke Nuisance (Scotland) Abatement Act, 1857, both of which are ineffective, and on the Burgh Police (Scot-

land) Act of 1892 for more specific burghal powers. Five cities in Scotland possess local enactments which vary in the extent of the powers they confer. The Corporation of Glasgow has its own legislation for dealing with smoke, contained in Section 31 of the Glasgow Police (Further Powers) Act, 1892, with subsequent amendments, the last being as recent as a few months ago. The difference between English and Scottish smoke legislation has often been described but may again be summarized because, when the burghal codes in Scotland and the relative powers in England are looked at attentively, they seem to me to differ fundamentally.

The Glasgow powers, obtained in 1892, are as follows:—

“Every person who so uses, causes, permits or suffers to be used any furnace or fire within the city (except a household fire) as that smoke, grit, gritty particles, sparks, ashes or cinders issue therefrom unless he proves that he has used the best practicable means for preventing smoke . . . being issued and has carefully attended to and managed such furnace or fire so as to prevent as far as possible smoke issuing therefrom,” shall be liable to a penalty.

Section 384 of the Burgh Police (Scotland) Act, 1892, is in almost identical terms except that it does not contain any reference to grit, etc., and exempts mines and certain metallurgical processes*; the Glasgow provision contains no exemptions.

It will be observed that these Acts make no reference to the colour or density of the smoke, nor do they require that the smoke should be in such quantity as to be a nuisance. The law simply says that if smoke is produced under circumstances where the best practicable means are not adopted and where due care is not exercised so as to prevent, as far as possible, the emission of smoke, an offence is committed. It is, thus, the emission of unnecessary smoke or smoke which could reasonably be prevented that constitutes the offence and determines the charge against the offender. These are wide powers, to be interpreted and administered with discretion, but in my opinion they place the administrator of the law and the defender in a sound position relative to each other. They are applied with reasonable regard for what is practicable and for what is proper to expect from those who are carrying on industry in the area. The peculiar merit of this kind of legislation is that it places the emphasis, not on the emission of smoke of a particular colour or density, but rather on the practicability of avoiding an undue emission of smoke. This, of course, means that where a prosecution is taken, the evidence in court will centre round the cause of the excessive emission of smoke and the various technical questions involved. The court will jealously protect those who can show that they use the best practicable means, but will be much less lenient where the cause is careless firing or lack of care in managing the plant, the use of inefficient plant, or plant in such a state of dis-repair that combustion conditions are adversely affected.

It would, of course, be absurd to assume that furnaces or fires can be operated without some smoke. A standard is necessary for the taking of observations, for obtaining *prima facie* evidence that unnecessary smoke is issuing from chimneys, for securing uniformity in legal proceedings, in short for the common sense administration of the law. I shall refer later to this standard, which is based on the use of the words “dense smoke.”

In England, the Public Health (Smoke Abatement) Act, 1926, enacts that an offence is committed if smoke escapes from a chimney in such quantity as to be a nuisance. What is meant by a “nuisance?” Local authorities are given power to define what they mean by a nuisance. Section 2 of the Act permits them “to make bye-laws regulating the emission of smoke of such colour density or content as may be prescribed by the bye-laws, and where such bye-laws are in force the emission of smoke of the character so prescribed for such period as may be prescribed in the bye-laws . . . shall, until the contrary is proved, be presumed to be a nuisance.” It eases administra-

* The exemptions are mines, the smelting of ores or minerals, calcining, puddling, rolling of iron and other metals, the conversion of pig iron into wrought iron.

tion and simplifies procedure if a statutory nuisance can be defined with reference to a standard, but in actual practice the problem is far from easy. I understand that 191 local authorities in England and Wales have had bye-laws confirmed under this section of the Act, and that all those bye-laws deal only with black smoke. It does not appear to have been possible to frame suitable bye-laws for anything but black smoke. I imagine that it would not be easy to find a practical standard for smoke regardless of colour.

I have referred to the use of the word "dense" in Glasgow to describe the kind of smoke aimed at by the law. Colour and density are two different attributes of smoke; dense smoke is not necessarily so-called black smoke but may be light brown or even greenish yellow. For instances, furnaces fired with pulverized fuel give out light grey smoke, while an approximately similar shade of smoke is emitted from incinerators and public works' destructors. Smoke from oxidizing processes is invariably of very light shade and may be orange, grey, greenish yellow, etc., but still dense smoke.

Introducing the English Public Health (Smoke Abatement) Act into the House of Commons in 1926, the Minister of Health said, "It is certainly time that power was given to local authorities to deal with smoke of other colours than black." Accordingly, Section 1 (a) of the Act gives this power. "A chimney (not being the chimney of a private dwelling-house) sending forth smoke in such quantity as to be a nuisance shall be deemed to be a nuisance . . . notwithstanding that the smoke is not black smoke." In this case, the person charged can plead that he has used the best practicable means for preventing a nuisance having regard to the cost and to local conditions and circumstances. When the smoke is black smoke, this defence is not available. The general position would appear to be, in brief, that if smoke is in such quantity as to be a public health nuisance it may be dealt with, but if the quantity does not amount to a public health nuisance it must be black before it can be dealt with. I regret that I am not sufficiently conversant with the administration of the law in England to know whether it has become an easy matter to prove the existence of a smoke nuisance, but I understand that difficulties have been met in dealing with smoke that is not black and that effective action stops short at the point where a smoke nuisance can be defined. Have many local authorities dealt successfully with smoke that is not black or with soot, ash, grit, etc.?

At any rate the difference between Scottish and English legislation is apparent. In Scotland it is the issue of unnecessary smoke that is aimed at, and it is left to the local authority and the courts to exercise common sense in applying the law to specific cases; the producer of smoke is left with an adequate defence. Scottish law tends to be functional, while English law tends to be mechanical. It is no doubt for some such reasons that a new departure is proposed in the English Public Health Bill to consolidate and amend existing enactments; Clause 101* proposes to regard as a smoke nuisance any installation for burning fuel or for working engines by steam which does not so far as practicable prevent the emission of smoke. This is an advance in a functional direction.

It is, of course necessary to set up standards of smoke emission on which to work. In Glasgow, by resolution of the Corporation, the standard adopted for prosecution is two minutes or over of dense smoke in any observation not exceeding sixty minutes. In England and Wales, of the 191 local authorities possessing bye-laws, the standard in 111 of these is a two-minute period in the half-hour, and in the remaining 80 the standard is a three-minute period of black smoke. The standard in Glasgow has changed with the times. The designation "dense smoke" was first used in the resolution of the Corporation about thirty years ago by the then Air Purification

* Clause 101 as proposed is as follows:—"For the purposes of this part of the Act (a) any installation for the combustion of fuel which is used in any manufacturing or trade process, or for working engines by steam, and which does not so far as practicable prevent the emission of smoke to the atmosphere; and (b) any chimney (not being the chimney of a private house) emitting smoke in such quantity as to be a nuisance, shall be statutory nuisances and are in this Act referred to as 'smoke nuisances.' "

Committee, when five minutes in an hour was adopted as the criterion. Subsequently this was changed to three minutes, then to two minutes in forty minutes and later to two minutes in the hour.

A few points of administrative detail in the day-to-day conduct of the smoke abatement service may be mentioned. (1) What is meant by "dense smoke?" Dense smoke is not necessarily black smoke. There is no scientific method of practical value for determining the density of smoke, but a workable procedure is adopted by the Senior Smoke Inspector and his staff who memorise and apply in practice the Ringelmann smoke charts of density. With these shades fixed in mind by experience, the various densities of smoke are finally determined in this somewhat arbitrary manner. It may be explained that the word "dense" has passed into current use among furnace users and in the court as describing the kind of smoke in respect of which proceedings may properly be taken. (2) If a case comes to court, the gravamen of the charge is not so much the emission of dense smoke as its cause, that is, failure to use the best practicable means of preventing the smoke or inefficient firing, in accordance with the terms of the statute. (3) It follows that the technical side of the smoke inspectors' work is of first importance, as the reference is to practical or technical issues, each case being judged on its merits. (4) To obtain prosecutions is not the primary function of the inspectorate. As a matter of fact, for every case that comes to court about forty are dealt with by warning, while advice and assistance are freely given to furnace users to enable them to avoid the emission of unnecessary smoke. If manufacturers and furnace users in an industrial area are to have confidence in the administration it is essential that the officers who come into contact with them should be able to discuss difficulties and to advise on technical matters. The law in Glasgow makes it necessary that this should be so. The inspectors visit the works to ascertain the cause of the unnecessary smoke. They are all qualified engineers, holding at least a first-class Board of Trade Certificate, and have had extensive experience of steam and furnace plant and possess an intimate knowledge of fuels.

The above paragraphs describe the scope of the law, with special reference to administration in Glasgow. For Scotland as a whole, general powers are required. The Report of the Committee on Scottish Health Services (issued in June of this year) points out that there has been complete unanimity in the evidence submitted that the existing legislation requires amendment, and that the statutory provisions applicable to landward areas are quite unsuitable. I hope that a general Act for Scotland will not be much longer delayed, and that it will follow the lines of the Glasgow provisions or of an amended Burgh Police Act, with increased penalties. I venture to think that Scottish as compared with English law is more serviceable for controlling smoke emission because of its functional character.

Observations on Atmospheric Impurities.

In most large industrial areas local authorities arrange for the measurement of impurities in and deposited from the air to be made by means of smoke gauges or air filters. These local observations are valuable for several reasons. (a) They enable the rate of progress of smoke abatement to be judged from year to year; (b) the statistical and pictorial evidence of pollution obtained are useful material for propaganda; and (c) they are of definite scientific value, as they provide data for systematic national surveys of the condition of the air of Great Britain. These records are collected from each contributing district, and are analysed and discussed in the Annual Reports of the Department of Scientific and Industrial Research on Atmospheric Pollution. Every area should co-operate with the Department in this work. Dr. H. A. Des Voeux, in his Presidential Address to the Sheffield Conference of the National Smoke Abatement Society in 1933, described very fully and ably the scheme for measuring atmospheric impurities and its scientific importance. He pointed out that it was a matter for regret that many local authorities had not yet associated themselves with the scheme, as the greater the number of observations taken, the greater their value.

It is important for each area to know, for practical purposes, just what its problem is, with the aid of consistent records. Each town has its own experience, and I may give some data relating to Glasgow conditions, as they are not quite the same as those of other places. (a) The soot deposited in the city area in 1935-36 amounted to 255 tons per square mile. Although this figure is large, the amount is only one-half of what it was twenty years ago; if the comparison were made with still earlier times, it would be even more favourable. (b) This reduced amount of smoke has markedly altered the character of fogs. Although fogs occur and recur probably as frequently as they did two or three decades ago, they are nowadays much less intense. Nevertheless, when they occur in association with cold weather or frost the effect on the vital statistics of the city may be disastrous. (c) A prolific source of pollution in former times was the factory chimney, and it may be cited as evidence of improvement that during the years 1899 and 1900, when five minutes' dense smoke was permitted, 17·5 per cent. of the observations led to intimations of excess smoke, as compared with 1·9 per cent. during the past three years, with a standard of two minutes. (d) Observations on the intensity of ultra-violet radiation reaching the city have not been sufficiently long continued to enable comparisons to be made with the past. Recent records, however, show that during the six summer months, 25 per cent. of the ultra-violet radiation is excluded from the streets in the centre of the city, as compared with that experienced six miles to the south-west of the city; during the six winter months at least half of the radiation is lost.

These observed changes in the amount of atmospheric pollution are mostly attributable to a lessened production of industrial smoke. What change, if any, has taken place in the contribution made by domestic smoke cannot be stated, but there is little doubt that the clearance of congested tenement areas under the Housing Acts has tended to lessen at least the concentration of smoke in many quarters of the city. The ratio which domestic smoke bears to the total pollution varies widely in different places; in Glasgow the proportion is roughly estimated as three to one, which may be taken to mean that of the 255 tons of solid impurities per square mile deposited, about 70 per cent. is derived from the domestic chimney—an estimate which reveals the magnitude of this problem which administration does not touch.

Observations on Improvements in Plant.

Reverting to the industrial chimney, one of the functions of local administration is to note such improvements in plant and its management as are calculated to further smoke abatement, and to assist this movement wherever possible. The principal causes of the reduction of smoke may be stated to be administrative action, co-operation with the users and owners of plants, improved types of plant, grading of fuel, more skilful firing and management of plant, increased use of gas and electricity for power and process purposes. For instance, gas is being widely applied in the steel industry, particularly in the Sheffield area. In so far as these improvements have become known to the Health Department they have been noted, and the following table has been compiled to show the alterations to furnaces, leading to abatement of smoke, which have been effected in Glasgow since 1900 :—

New steam boilers installed to give increased power	251
Mechanical stokers fitted to steam boilers, replacing hand firing	387
Secondary air smoke preventers fitted to steam furnaces	279
Furnaces in which anthracite, coke, or other non-bituminous fuels have been substituted for ordinary raw coal	324
Steam boiler furnaces adapted for the smokeless combustion of oil fuel	7
Steam boilers replaced by electric motors (using public supplies)	220
Furnaces in which gaseous fuel was substituted for coal firing, and steam boilers replaced by gas engines	233

New chimneys erected or existing chimneys heightened to give increased draught to carry gases higher	266
Improvements to furnaces not coming under any of the above headings	94

This table gives a general idea of the improvements which have been made by plant users. It is being realized that the older and more inefficient methods of fuel combustion and power generators are uneconomical, and that compliance with the standard of smokelessness now demanded by public opinion and by statute requires up-to-date installations giving high thermal efficiencies and almost smokeless combustion. Much greater use is being made of electricity or gas as the power medium by progressive plant users.

Pollution caused by steam waggons also comes under notice. Under the Road Traffic Act over 80 prosecutions have been taken against drivers. Up till two years ago there might be some 200 steam road vehicles daily in the streets in and around the city, but their number now probably does not exceed a few dozen. The Standing Orders of the Corporation require that vehicles employed on Corporation contracts and sub-contracts must use fuel of a smokeless nature. As the result of experiments carried out by the Senior Smoke Inspectors, all tar melters have now been persuaded to use coke.

Courses of Instruction in the Use and Management of Plant.

To prevent unnecessary smoke, a furnace or fire should be "carefully attended to and managed," as the law requires. It is obvious that a knowledge of boiler-house practice, methods of firing, the principles of combustion, and so on, will be of great advantage to those responsible for the working and managing of plant. The establishment of suitable courses of instruction has become, therefore, an important duty of a local health authority, and it is well worth while to devote the greatest care in developing these courses on a sound and attractive footing and to make them a success, as they are a service to industry as well as a service to the administration. Classes for firemen were begun in Glasgow in 1910, and were reorganized in 1920 on their present basis; they are conducted under the auspices of the Smoke Abatement Society and the Corporation of Glasgow. Upwards of 2,000 men have passed through these classes since they began. Those attending the ordinary and advanced winter courses now include stokers, boiler attendants, engineers, chemists and executives, and others connected with allied occupations. There is no doubt about the great practical value of these courses because the results are excellent. Plant owners and users obtain men instructed in the careful and economical use of plant and fuel, and the cause of smoke abatement is directly and definitely promoted. Classes of this kind have been set up in many centres, but there is room for a wide extension of these facilities. An important practical step has recently been taken—the setting up of a central examination and the granting of a National Certificate in boiler-house practice by the Department of Technology of the City and Guilds of London Institute. This certificate will provide candidates from local teaching centres with supplementary national credentials, and it is to be hoped that the training given and the certificates granted will become generally accepted by industry as qualifying for the management of plant. This movement is one which should be strongly supported and widely recognized.

Investigation into Methods of Smoke Prevention.

Local authorities are aided in their smoke problems by a number of national bodies, such as the National Smoke Abatement Society, which is representative of their interests, renders substantial assistance in propaganda, and provides a medium for the discussion of difficulties; the Fuel Research Board; the Institute of Fuel; the Committee for the Investigation of Atmospheric Pollution of the Department of Scientific and Industrial Research and its associated Standing Committee of Co-operating Bodies. The scientific work carried out by these bodies is of great value to

local administration, because it provides a background of knowledge which enables those who are dealing with smoke problems to be well informed and to keep abreast of technical advances in their application to smoke abatement. The Public Health (Smoke Abatement) Act, 1926, recognizes the need for continued research and authorises local authorities to undertake investigations and researches into problems relating to atmospheric pollution or to contribute towards their cost.

The Newton Committee, which reported in 1921, recommended the granting of this power to local authorities; in doing so they mentioned specially "the encouragement of research into domestic heating problems generally." The Minister of Health, introducing the Public Health (Smoke Abatement) Bill into the House of Commons in 1926, said:—

"As regards the domestic problem, the solution lies in two directions; one is in making it as easy and as cheap as possible for people to use gas and electricity, and the other direction is in the use of smokeless fuel. If we can obtain a smokeless fuel which can be used in the open grate and which is sufficiently cheap and sufficiently practicable to commend itself to the ordinary man and woman, then I think we may be able to amend this by putting in a provision to allow local authorities to exercise control over the burning of raw coal in grates."

How much progress has been made in these two directions in the ten years that have since elapsed? Gas and electricity are now much more commonly used in the domestic field where they can be obtained easily and cheaply. Propaganda in their favour is carried out by many local authorities, and one of the best ways of doing so is by means of exhibitions of modern household appliances for cooking and heating. There is a definite relationship between the cost of gas and electricity and the state of the air. Where these alternatives to coal are easily and cheaply obtained, their use for both industrial and domestic purposes rapidly increases. This has been the experience in Glasgow where the rates for these services are among the lowest in the country. The consumption of electricity in the Glasgow area has increased by over 45 per cent. in the last five years. But what is to take the place of the open coal fire? Is the day any nearer when the burning of raw coal in open grates can be prohibited even in housing schemes? Is the science and art of heating and ventilating dwelling houses sufficiently well understood to enable a dogmatic answer to be given? In my view, the principal requirement is a good smokeless fuel such as will commend itself to the average householder. This demand has not yet been met, such supplies as are available being local and restricted.

Areas of Local Administration.

It is held in many quarters that local administration would be more efficient if it embraced wider areas than it does at present. The Public Health (Smoke Abatement) Act of 1926 recognised that it would be advantageous to have uniform administration of the law over a large industrial field in which there might be several responsible authorities. Accordingly, it enabled one or more local authorities to appoint a joint committee "to carry out their duties in respect of smoke nuisances." One such statutory committee, the Sheffield, Rotherham and District Smoke Abatement Committee, has been in operation since 1930; it succeeded the former Sheffield and Rotherham Joint Smoke Abatement Committee which was formed in 1927. The area covered amounts to 133 square miles with 3,890 working chimneys in a highly industrial district. Alongside this statutory committee there are two other committees, a Committee of Manufacturers and a Joint Advisory Committee under the chairmanship of Professor R. V. Wheeler of the Department of Fuel Technology, University of Sheffield, the main function of which is to prosecute scientific research. During the last few years regional smoke abatement committees with purely advisory functions have been set up in other areas, such as for Manchester and District, the West Riding of Yorkshire, West Lancashire and Cheshire, Northumberland and Durham, the

Midlands Joint Advisory Council. The Greater London Joint Smoke Abatement Committee, consisting of representatives of local authorities and of industrial interests, was formed for the specific purpose of framing bye-laws.

In Scotland, as I have explained, there is no general Smoke Abatement Act and there are no joint committees. I may, however, quote the views of the Committee on Scottish Health Services. The Report says, "It has been pointed out to us that a local authority may be administering the statutory provisions in such a way as to secure reasonable compliance and still suffer because of the failure of an adjoining local authority to deal with the problem adequately." The Committee regard the abatement of smoke as one of the public health services for whose efficient administration a broad regional view should be taken. They recommend that "the Central Authority should be empowered to make effective provision for combination in suitable circumstances," and that "our general proposals for co-operation among local authorities should apply to this service." One of the major problems of to-day is how to adapt certain branches of local public health administration to modern conditions and requirements. It seems to me that the smoke abatement service is very much a case in point where the Central Authority should see that the work is properly done and should be in a position to require combination of local authorities in suitable circumstances. There are marked inequalities in the effectiveness of the work performed, and administration would gain by being spread over wider areas than at present. An administrative advance of this kind would bring certain advantages. (*a*) There would be uniform standards for smoke emission throughout the area, uniformity in applying the law, and one system of inspection and prosecution; (*b*) there would be maintained an adequate staff of technically qualified inspectors for what is in fact a technical service, a staff capable not only of dealing with producers of unnecessary smoke on their own ground, but also of co-operating with and advising the owners and users of plant; it is particularly necessary to watch the small hand-fired boiler which is often carelessly used; (*c*) courses of vocational training for firemen, boiler attendants and others would be available over wide industrial areas; (*d*) in short, combination for statutory and administrative purposes would enable the functions outlined in the preceding paragraphs to be exercised on a broad regional basis.

It would, perhaps, have been better had the opening paper on public health administration been introduced by someone who could have dealt more fully with the position south of the border. I have naturally based my remarks on Scottish affairs and on the measures in operation in Glasgow, using them to illustrate the more important functions and responsibilities of local authorities with regard to smoke abatement. While some of the points raised are of common interest, several omissions will be noticed. I have not referred, for instance, to the question of exemptions, whether these could not be decided locally in the first instance with right of appeal to the Central Authority; the absence of bye-laws for the prevention of smoke in new buildings other than dwelling houses; the efforts to solve the problem of standards for other than black smoke (if there is a solution); the important question of the evolution of sulphur gases in the combustion of coal. These and other topics which arise out of the provisions of the 1926 Act for England and Wales, and which cause much controversy, will no doubt be dealt with in the discussion. The problem of most vital interest to local authorities, the domestic smoke problem, has only been touched upon; it is being discussed at another session of the Conference.

In a paper on smoke abatement emanating from Glasgow, it would be wrong not to refer to the very great services to the administration in the city rendered by Councillor W. Brownhill Smith and by Councillor Alexander Munro and to their pioneer work in the cause of air purification. In preparing these remarks, I have drawn freely upon the able work and long experience of Mr. Thomas M. Ashford, A.M.I.Mech.E., the Senior Smoke Inspector in the Public Health Department.

SMOKE AND THE SANITARY INSPECTOR.

By HERBERT G. CLINCH, F.S.I.A., M.R.S.I.,
Chief Sanitary Inspector, West Ham County Borough.

On consideration one is shocked to realize that one has been engaged for a quarter of a century in doing one's little best to improve the sanitary condition of the sky. During those years, one has lived in a town populated by coal producers to whom output is of vital consideration and to whom the manner of its use is naturally one of indifference. One has also lived in what may be termed a town of coal-users to whom coal formed an expensive part of their costs of production. One next lived in a community almost entirely ignorant of the process of coal production and happily possessing little experience of its use.

One's official duty is to prevent excessive industrial smoke emission so far as the powers of the Public Health Acts provide. In this direction, the Sanitary Inspector is the only officer of a local authority who can achieve any success. He can, if he will, acquire practical as well as theoretical knowledge of the running of steam raising plants and by his opportunity of studying such a large number and variety of plants, can develop a sixth sense enabling him to deal effectively with common combustion problems. So, by co-operation with industry and with those engaged therein, an efficient sanitary inspector becomes more than a smoke policeman; he becomes the watchful father of a large family of coal-grimed steam raisers.

At the town of coal users—Halifax to be precise—one had the advantage of breaking virgin ground. Nothing had been done previously except for the routine observation of factory chimneys and the service of notices in respect of any offenders against a "five minutes in sixty limit." As fifty years of this treatment had not proved successful, other methods were obviously needed. One's first step was to acquire at a local boiler makers' works, a useful experience of boiler construction and next to apply one's theoretical knowledge of combustion to plant running, on Sundays and evenings, under the kindly hand of a local boiler house wizard who had spent his life in making one pennyworth of coal do the work of two.

Having obtained the freedom of action essential to success, one's next step was to address meetings of the local firemen and stokers at their own Union meetings where the atmosphere was conducive to plain speaking. One there taught the hard-worked underdog, the man with the shovel, the true inwardness of his job. One taught him there and in his own boiler house that the more steam he obtained from his coal, the less he had to shovel, but he was also taught that the discharge of smoke was an offence against the lives of his fellow-men. Meetings of the engineers in charge were then addressed at their trades clubs and they were taught the fallacy of calculating working efficiencies in terms of pounds of water evaporated per lb. of coal, a custom which led directly to the use of rich, gassy, and therefore smoky coals. They were impressed in season and out of season with the fact that the true test of an engineer's skill was: "how much steam he could produce per £," and if he could produce more steam per £ sterling than another man, even if he used more weight of coal but of a cheaper type, he was a better engineer and a more valuable man to his employers.

A card of hints to Boiler Attendants was prepared and distributed by the Health Committee with good effect (H. K. Lewis & Co. Ltd.).

By standing up to constant questions at the meetings of stokers and engineers, one gained their confidence and one's visits to boiler houses became friendly and welcomed. The men's mentality had been changed from one of dread, dislike and distrust, to a sporting attitude of "Do your best to keep the chimney clean, Bill, the big fella won't like it if he sees any smoke." The conversation accidentally overhead showed progress of the most useful kind.

The Manufacturers' Part.

At this stage one learned that the efforts of the men were not being encouraged and one was amazed to find that many manufacturers were content to pay for coal as it was required and never bother to find out whether it was being used efficiently. One then addressed the owners at Chambers of Commerce, Rotary Clubs, etc., and indulged in plain speaking, on the foolishness of 100% business men demanding cards of efficiency in every department except in their power plants where they spent the most money. A few examples of amended methods on one's own advice effected startling economies in working, thereby producing the necessary confidence, and things began to progress rapidly until one very rarely saw an excess of $1\frac{1}{2}$ minutes in thirty, the limit decided upon. As the savings effected by steam users amounted to many times the amount of one's own salary, this result was not surprising.

One took part in that very active body, the West Riding Regional Smoke Abatement Committee, and it was hoped that the establishment of regular courses of training for stokers, followed by examinations for certificates of proficiency, would have led to the raising of the wage rate for certified stokers, but the response was disappointing.

As industrial smoke does not represent the whole of the air pollution, the domestic field was attacked by means of constant addresses to meetings, by articles written for the popular Press, by broadcasting, etc., until one's whole life developed into incessant work. The result, however, was achieved: the whole town became smoke-conscious and it became recognized that smoke emission was a disgraceful act. It became common for people to call at the Public Health Department for advice on the smokeless heating of their homes.

This result was achieved by a sanitary inspector, given an entirely free hand, and blessed (or cursed) with the burning fire of enthusiasm.

Be it noted that the whole of the time available was devoted to stopping smoke and not one minute to taking charge of soot deposit gauges, working up charts of results, and dabbling in statistics intended to prove that the smoke is not our own smoke, and that it comes from the next town or county. The Sanitary Inspector is the technical officer of the Public Health Service, and should devote his attention to matters technical, leaving matters medical to those qualified to deal with them. Matters clerical should be worked out by the professional clerk, but under the guidance of the inspector.

To the local authority I would emphasize the fact that the Sanitary Inspector is not a sanitary policeman; he is the main instrument whereby a population can be induced to achieve for themselves better conditions of life.

Public conscience has now awakened to the value of sunlight; shown the way by practical people and not by irresponsible talkers, our people will adopt smokeless methods. The fact that smoke represents a waste of money to the person who produces it, and incalculable injury to those who breathe it, should never be forgotten. The weight of soot produced gives no indication whatsoever as to the amount of heat which has been wasted during its production. Soot costs gold to produce.

Much harm has been done to the cause of smoke abatement by well-meaning individuals who will persist in saying that a certain proportion of the carbon of the coal burnt in the domestic grate is transformed into soot, but who cannot stand up to questions because they have nothing to offer in lieu. Health reformers lash themselves to indignation at the condition of the atmosphere, but they have nothing to offer the manufacturer or the housewife and they do more harm than good.

The Need for Enthusiasm.

A method of successful smoke abatement has been outlined but no man can be "directed" to perform such a service. Enthusiasm, and only enthusiasm, is the essential to success and local authorities should see to it that the Inspector is not subjected to irritating and restricting conditions which serve only to stifle his efforts at their birth, and in fact make impossible any progress beyond the policeman attitude.

Local authorities should own their gas and electricity undertakings and run them as joint heat, light, and power producing plants. They should then produce these products at cheap rates and sell at cheap rates so that the privately owned power plant simply would not pay to use. Sell electricity cheaply for power and light, and gas and coke for heating and boiling. The small works power plant running at, perhaps, only 65 per cent of its possible efficiency and producing its quota of death dealing soot should be, and I believe could be, put out of business by a real live selling policy of gas, coke, and electric power.

A nation is to be judged by what it does with what it has and if this be true, what will be the verdict of posterity upon we of the smoke age for our neglect of our opportunity to clean up our sky and to save immense sums of money annually by doing it.

Sanitary Inspectors, devote all your available time to stopping smoke production! Councillors, get out of the rut of party issues, treat air pollution as the national calamity it certainly is, combine all forces in a great reform for the common good.

Remember, Councillors and Sanitary Inspectors, that you all are compelled to breathe the air spoilt by your neighbour's coal fire, so sell him smokeless methods at prices which will induce him to use them.

A last word: "Burn your refuse and save your rates," providing you have a suitable fire upon which to burn it. If not, please, please, please, do not burn your refuse in your dustbin, leave it to the local authority to burn in bulk under proper conditions. Please don't do it!

JOINT DISCUSSION

Dr. Veitch Clark (Manchester) said how fortunate the Conference was in having two papers which presented so many facets of the problem in connection with the administration of smoke legislation. It was, he said, impracticable to attempt to deal with many of those under discussion and he therefore proposed to confine himself to one issue, which was the formation of statutory bodies for smoke control covering larger areas than those of any individual health authority, in other words the formation of joint statutory smoke boards parallel in the general sense to the Rivers Boards already existing in the country.

The Manchester and District Regional Smoke Abatement Committee had spent a great deal of time on this subject and had in fact published its considered opinion in full. Their opinion was that only by the formation of such joint boards for the Manchester and district area could one hope to attain uniformity of administration of smoke legislation and the control of the improper emission of smoke in all the local authorities in such an area. The speaker desired to support this view as strongly as possible. In his opinion no other method of administration could ever hope to attain a reasonable degree of success. In such an area as South-East Lancashire the local authorities varied from large cities to small urban or rural districts. In many of these small areas it was not possible to provide the staff required for the efficient administration of smoke law. The sanitary inspector had had his work trebled in recent years, and the great pressure of other insistent demands upon his time made smoke in-

spection either a travesty or caused it of necessity to become completely neglected.

The financial position of these smaller authorities was such that to appoint an additional inspector would mean a very definite increase of the rates since the yield of a penny rate was very small. In most of these areas smoke emission was a very serious problem and however carefully these areas (which could afford proper smoke inspection) did in fact carry out their statutory provisions the problem of the atmosphere from neighbouring districts where this was not practicable had affected the whole area. The persistence of a great pall of smoke was a matter of common knowledge and needed not to be stressed except to refer to the extra evidence afforded during recent years by the difficulty in flying over the industrial parts of the country. The Manchester and District Regional Smoke Abatement Committee had made two extensive series of observations over their area, and in the outer regions industrial smoke emission was found to occur much more frequently than in the well-administered areas—the difference being 30 times greater smoke emission pro rata in some areas as contrasted with the relatively good areas. The facts of the case were beyond dispute.

The advantages of joint boards were numerous and one needed only to refer to a few of them. The first was that such a board could be established and run in the Manchester and adjoining areas at a cost of not more than one-ninth of a penny rate on the constituent authorities. The second was that such a largely representative body would have

great weight with public opinion and would be able to employ the services of skilled fuel engineers in advisory capacities to a degree which was not practicable to the local authorities at the present time. Its work in this respect would always be far more that of a helpful than a penal authority, and this was essentially one of the things they had been striving for throughout their whole existence as a smoke abatement league. The standard of administration of the law would be stabilized. Its requirements would become much more generally known and public opinion would steadily increase in its support and altogether, there could be no doubt but that the joint board would function with a degree of success far beyond that which was possible to the disjointed practice—often the complete inertia—of separate and independent local health authorities.

Mr. George W. Farquharson (Birmingham) said that in reply to Dr. Macgregor's question, "Have many Local Authorities dealt successfully with smoke that is not black, or with soot, ash, grit, etc.?" he could assure him that as far as his Authority, the City of Birmingham, was concerned, they have dealt successfully with coloured smoke emissions.

In regard to soot, on September 17th, 1935, a magistrate's order and costs was obtained for the abatement of soot emissions from an annealing furnace. As far as he was aware this was the first and only case of its kind in England under the Public Health Act, 1875, and Public Health Smoke Abatement Act, 1926. He would also like to draw attention to the fact that the process of annealing comes under the so-called exempted processes. They had also dealt successfully with emissions of wood ash and grit.

Finally, he would like to ask Dr. Macgregor whether the river craft on the Clyde were subject to the same smoke abatement legislation as that prescribed for shore establishments.

Mr. Thomas M. Ashford (Glasgow) said he was very pleased the chairman had expressed the opinion that propaganda and advice were very important factors in smoke abatement work.

Dr. Macgregor during his paper had referred to the apparent mechanical nature of English legislation as compared with the more functional character of Scottish powers. In the Scottish statutes there was no attempt at a definition of prohibited smoke, much less of permissible duration of emission, but rather stress was laid on the question of the best practicable means being employed "so as to prevent as far as possible the emission of smoke" and while the onus of proof as had been stated was on the furnace user yet in actual practice it was on the Local Authority to prove their contention that reasonable or the best practical means had not been adopted. In this way legislation was definitely functional.

The word "black" when referred to smoke meant very little as the shade or apparent tint had very little relation to the deleterious nature of the emission.

The matter of exemptions was a much debated point under the 1926 Act. In Scotland, under the general burghal powers, there were a number of exemptions stated and because of this in Glasgow, where no exemptions were stated, actually in practice certain metallurgical furnaces were exempted because it was felt that it would be unfair in any way to impose restrictions on these industries whose competitors in outside areas were unrestricted.

Dr. Macgregor had referred to the deconcentration of smoke, so far as density was concerned, in many quarters due to the clearance of congested areas, but was the collective volume of smoke lessened. He very much doubted so, because all the newer houses were fitted with the modern open fire, frequently of the well type, which so far as the burning of bituminous fuel was concerned was not nearly so efficient as the old-fashioned type generally met with in the older houses which giving much greater depth of fire, and greater conservation of draught, was certainly more smokeless in use. He had been observing some of the new suburban housing areas and the smoke pollution during the mornings, early forenoons and late afternoons was appalling—and that over wide areas.

It was remarkable how little had been said during the conference about smokeless fuels. Their possibilities had always been very much to the forefront at previous conferences, and one would imagine that there had been concerted propaganda in the discussion re the advocacy of the suitability of bituminous fuel for domestic purposes. Much had been said about the re-design and improvement in design of the newer domestic fires for this purpose, and some success might be attained under test conditions, but it was to be remembered that the average housewife when harassed by her multifarious household duties had very little time to devote to smoke abatement, and if she was dealing with a plant which is by no means efficient for the purpose of burning bituminous fuel he was afraid little definite progress could be looked for in that direction. From a psychological and ventilation standpoint the open fire was likely to remain, and that being so the only solution for the domestic component of the problem was, in his opinion, the extended use of gas and electricity and the use of solid smokeless fuels.

Dr. Macgregor had referred at some length to the desirability of areas of local administration, and he hoped the time was not far distant when they in the North would have regional committees comparable with those of the South, preferably of a statutory nature. If and when such co-ordination becomes a reality many of the anomalous positions now existing would be swept away and uniform

methods of administration and control would then be possible.

Mr. H. L. Pirie (Chief Engineer, the Coal Utilisation Council) said he commended to all Sanitary and Smoke Inspectors who had to administer the Smoke Abatement Acts the two papers to which they had listened that afternoon.

While none of them wished to condone smoke it was just as well to keep a balanced outlook and he was glad to think that at least in two places, Glasgow and West Ham, Smoke Inspectors appreciated the difficulties of certain combustion operations.

To meet the manufacturer and offer constructive suggestions for overcoming his smoke difficulty would get you much further than adopting the attitude, as some smoke inspectors did "There's the law, smoke must be stopped and it is no business of mine how you stop it."

The Coal Utilisation Council had nine combustion Engineers on its staff and their services were frequently used by smoke inspectors, and the Manchester Regional Smoke Abatement Committee. For example, in a certain district if the inspector had reason to complain of smoke omission, his first step was to notify the offender and suggest he get in touch with the C.U.C. Engineer concerned. Between June 9th and September 2nd that year, 54 plants had been inspected and advice given by their Manchester engineer in response to a circular sent out by the Manchester Regional Smoke Abatement Committee.

The Lancashire boiler for the combustion of bituminous coal was fundamentally wrong, but it had remained a firm industrial favourite for two reasons, first it was fool proof, and secondly it acted as a heat accumulator. He would be a bold man who would prophesy the early demise of the Lancashire boiler, but it might interest the meeting to know that only the other day a colliery manager to whom he was speaking informed him that he was scrapping his Lancashires and putting in water tubes in spite of the peak loads resulting from his three winding engines.

While, he thought, they could reasonably claim to reduce industrial boiler smoke below a nuisance value, grit emission was very troublesome and although he had recently examined several new grit arrestors, their cost was unfortunately prohibitive. A cheap efficient grit arrestor was urgently required.

Bailie A. Munro (Glasgow) said that the ventilation of a room by a coal fire caused draughts, for it brought in too much cold air and therefore could heat the room. There had been many houses built which were well ventilated, and were all electric.

He quoted passages from the report of the Committee on Smoke and Noxious Vapours abatement with regard to domestic smoke.

Bailie Munro gave the results of the recent

examination held by the City and Guilds of London Institute on Boilerhouse Practice, which had been held for the first time. He thought the results were very gratifying, there being only 26 failures out of 112 entries.

Councillor C. Ramsell (Nuneaton) said the author of the second paper was very provocative in the last part of this paper which suggested public ownership and the controlling of Local Councils of means of production and distribution of lighting, heat, and power. He agreed public ownership was imperative to achieve the ideals of the Smoke Abatement Society, because profits derived from those sources could be utilized to giving rebates of various appliances and tariffs. He gave an illustration of government through public ownership and production, producing electricity for light and power at less than a 1d. per unit and protests had been made to the Central Electricity Board, owing to distribution being left to private enterprise, by Rural Local Authorities who objected to being charged anything from 5d. to 8d. per unit and that private profit taking should stand between the benefits of public ownership and low tariffs conducive to abolishing the menace of atmospheric pollution and its effect on Public Health. The case obviously should be if public ownership could produce cheaply then it should be allowed to pass on those benefits by such distribution.

He disagreed that Councils should be independent production and distributive units and said local authorities should be constituent parts of a central authority for production of heat, light, and power: in effect a Central Electricity Board with power to produce and distribute, controlled by the Government with a Minister in charge of the policy outlined. He concluded by saying it was futile to advocate smoke abatement unless the ideals and solutions offered were possible of operation in all classes of the community financially and economically. He apologised for his criticism and closed his remarks by saying that Mr. Clinch, in his fearless but practicable manner, was contributing something capable of success.

Mr. James Law (Sheffield, Rotherham, and District Committee) said that three of the large cities—Glasgow, Liverpool and Birmingham—all had local Acts, which were much more simple to work than the lengthy procedure of Statutory working under the Public Health Act.

He had been a Smoke Inspector for 17½ years, and had worked both Local Act and Statutory Act, so that he could appreciate the difference in the working. It took at least three months before any pressure could be brought to bear on offenders when working under the Public Health Act.

With regard to bye-laws, the 1926 Act, Section 2, stated that local authorities could make bye-laws "regulating the emission of smoke of such colour, density or content as

may be prescribed." The man who worded that section must have been a manufacturer with a number of very smoky chimneys, because how bye-laws were to be made which included all these conditions, he could not imagine. If he were asking the Ministry of Health to grant bye-laws regulating the emission of smoke he would ask for those conditions to be expressed as "Excessive" smoke and prove to the Magistrates that the smoke could have been avoided. This would be done on similar lines to the Glasgow Inspectorate who use the expression "dense" smoke.

With regard to "grit" and "grit emissions" they are difficult to deal with, but by means of grit slides sufficient evidence can be put forward to convince Magistrates that the smoke is emitted from a particular chimney. It needed rather a lengthy explanation for which he had not the time to deal, but he would be pleased to give any information if it was desired.

A large sugar refinery was fined on two occasions for grit emission and the evidence was quite convincing on each occasion. These proceedings were taken under the Local Act and not under the Public Health Act, but he was quite satisfied that the same methods could be used.

The Chairman had asked if anything had been done about the emission of sulphur and sulphurous gases. In Sheffield and Rotherham where crude coke oven gas was being used for metallurgical processes, they had been very concerned about the amount of sulphur emitted, and had found it necessary to collaborate with the Alkali, etc., Works Regulation Act Inspectors from the Ministry of Health in order that samples of the flue gases should be tested. A number of tests had been taken, and though it had been surprising how high in sulphur these results had been, they had not been considered sufficiently high to become a menace. For boiler chimneys the percentage of sulphur was fairly low. The matter would not be allowed to lie in abeyance, but further tests would be made periodically.

Mr. J. W. Beaumont (Halifax) in referring to Dr. Macgregor's paper, said that he was afraid that local authorities were not taking full advantage of present opportunities of making a notable contribution towards the diminution of domestic smoke. At the present time a great campaign of slum clearance was in progress throughout the land and thousands of new houses were being built to rehouse the erstwhile slum dwellers. Did all housing authorities carefully consider all available means of heating those houses smokelessly before coming to a decision upon the matter? He was afraid they did not. Although he deprecated any dogmatic statements as to the relative value of electricity, gas, or solid smokeless fuel, he was of opinion that all these forms of heating should be carefully considered having regard to their practicability from all points of view

and ever bearing in mind the economic aspect of the question, before deciding upon the particular form or forms of heating to be employed.

In speaking upon Mr. Clinch's paper, Mr. Beaumont said that, as one who had succeeded Mr. Clinch as the Chief Sanitary Inspector of Halifax, he felt impelled to pay tribute to the good work he had accomplished there in the cause of smoke abatement. It was, therefore, with some diffidence that he ventured to criticize his paper. Time would only permit of his referring to one point, however. It was, he said, quite evident that Mr. Clinch had a rooted aversion to Sanitary Inspectors having anything to do with atmospheric pollution gauges, records, etc. Why? Did not Mr. Clinch recognize the value of research in this direction, or was it merely that he thought Sanitary Inspectors should take no part in it. Mr. Clinch had told them that he had addressed public meetings, written articles for the popular Press and broadcast upon the subject of smoke abatement, and Mr. Beaumont suggested that had he been in a position to refer to local atmospheric pollution records he might have given greater point to his arguments and have greater impressed his listeners. Mr. Clinch had said, "the weight of soot produced gives no indication whatsoever as to the amount of heat which had been wasted during its production." Surely, Mr. Beaumont said, that was a matter of primary concern only to the person paying for the wasted energy. On the other hand, the weight of soot produced was an indication of the potential danger to the health of the community in that area, a matter of vital importance to the whole nation.

Again, Mr. Clinch had stated that the public conscience had now awakened to the value of sunlight. Was this literally true, asked the speaker, because if so there would now appear to be no need for such bodies as the National Smoke Abatement Society, which existed primarily for the purpose of bringing home to the public conscience, the evils of smoke. Was it not more correct to say that the public conscience was stirring in its sleep and that intensive propaganda was more than ever necessary to insure that it thoroughly awakened to a full realization of the ill effects of smoke and the necessity for adopting measures for its prevention? One of the most valuable aids to such propaganda was the judicious use of information obtained as a result of obtaining records of atmospheric pollution, daylight, etc., and in such work the Sanitary Inspector should play his appropriate part.

Councillor T. Turner (Paddington) asked if Mr. Clinch would be so good as to amplify the final paragraph of his paper, in which he referred to the "slogan" issued by some local authorities—"Burn your refuse and save your rates"? What exactly did Mr. Clinch mean by a "suitable fire" for such a purpose? His

experience in a thickly-populated area, where most people lived in tenement houses, was that very few had fires suitable for burning refuse. Was it not dangerous, from a public health point of view, to urge people to burn their refuse in such an area?

Dr. Macgregor, in reply, said that he welcomed the strong views of Dr. Veitch Clark in favour of the setting up of statutory regional committees, which should be endowed with wide powers and which would consider the smoke problem from a wide angle. He agreed that a great many advantages such as had been outlined by Dr. Veitch Clark would accrue to the smoke abatement movement, particularly if legislation to control the emission of smoke from industrial chimneys was functional in character. On the question of domestic smoke, which had been very fully discussed at the Conference, there was the usual difference of opinion as to the merits of coal, smokeless fuel, gas and electricity. No doubt the position would become clearer with further experience and in the light of actual experiment. Heating and ventilation were closely allied, and the primary condition of a heating installation was that it should be in agreement with the principles of ventilation as well as with those of heating. Some methods in vogue for heating rooms in dwelling houses did not take sufficient account of ventilation, and he thought that a good deal of study was still required on these twin problems. In reply to Mr. Farquharson, he pointed out that the river craft on the upper

reaches of the Clyde within the jurisdiction of the Port was subject to the same smoke abatement legislation as that prescribed for shore establishments.

Mr. H. G. Clinch, in his reply, said that it was obvious that certain parts of his paper had been misunderstood by those who lacked experience of conditions in the Greater London area.

With regard to the keeping of records and undertaking the care of soot gauges, sunlight recorders and the Lord knows what other kind of gadgets, he said that his point had always been to teach the people the evils of dirty air, but in order to achieve results be prepared with a remedy, and it is far more important for a Sanitary Inspector—the only officer of the Public Health Department who can do so, to show all classes of the community the remedy, and if he did this he would have no time available for the keeping of records and the care of instruments of the nature mentioned, and this could quite well be left to the less technically minded people.

He would remind his audience that never on any single occasion had he stood before any meeting to preach the evils of smoke without being at the same time prepared to face up to questions at the end and to answer those questions and suggest a practical and economical remedy. Unless the smoke problem were dealt with on those lines, propaganda would be no more effective than propaganda against the evils of the east wind!

List of Publications

(All prices include postage. Reduced prices for quantities).

NEW PUBLICATIONS.

Handbook and Guide to the Science Museum Exhibition. The Handbook is not only a detailed guide to the Exhibition, but containing a series of twelve authoritative articles on the main aspects of the problem, is a permanent and useful reference book. There is a foreword by the Minister of Health, and in addition there is a series of communications from correspondents abroad on progress being made in other countries. 80 pages. Medium 8vo. Price 6d.

The Case Against Smoke. A new booklet which is intended to give the reader a clear understanding of the nature and extent of the smoke nuisance by means of passages from a number of writers and speakers, each of whom may be regarded as an authority in his own sphere. There are also figures and extracts from official reports and tables. Invaluable for those who write and speak on the subject. 14 pages. 4to. Price 3d.

The Journal of the N.S.A.S. The Journal is not a record of proceedings but a magazine—the only one in the world—devoted to the problems of atmospheric pollution. Contains authoritative articles, notes on technical subjects, news of activities of every kind, and in general keeps the reader up-to-date in every aspect of the subject. Per annum, 2/6. Gratis to members.

The Law Relating to Smoke and Noxious Fumes by the late Randolph A. Glen, M.A., LL.B., Cantab, (Editor of "Glen's Public Health," etc.). With a foreword by Sir Lawrence Chubb. A comprehensive and practical survey of the legislative side of the problem, written by an authority. 8vo. pp. 24. 1/-.

Fumifugium; or the Smoake of London Dissipated, by John Evelyn. This rare and fascinating book, first published in 1661 by command of Charles II., has been republished by the Society with an introduction by Miss Rose Macaulay. In spite of its age this indictment of the smoke evil by the author of the famous Diaries remains true, witty, and penetrating. Illustrated with original wood engravings and a portrait of Evelyn. Paper covers, 6d. Cloth-bound, 1/6.

Smoke and Fumes Nuisances from Road Vehicles. The technical and scientific aspects by Dr. J. S. Owens, A.M.Inst.C.E., M.I.Mech.E., and the legal position by R. P. Mahaffy, M.A. 8vo. pp. 16. 3d.

Smoke and Health by Dr. J. S. Taylor, M.D., D.P.H., Assistant Medical Officer of Health, Manchester. 8vo. pp. 12. 2d.

Smoke and Aviation. Full Report of the 1935 Conference on this subject. Four papers in full and discussions. "Smoke and Visibility" by C. S. Durst, B.A., Assistant Superintendent, Meteorological Office, the Air Ministry. "The Effects of Smoke upon Flying Conditions" by William Courtenay. "The Effects of Smoke upon Flying in the North" by Alan Goodfellow. "Visibility and Smoke in Relation to Aerial Photography" by Captain Alfred G. Buckham, F.R.P.S. With photographic illustrations. 8vo. pp. 40. 1/-.

Smokeless Open-Grate Fuels. Report of the Symposium held in 1934. Papers and discussions on all types of solid fuels, their uses and requirements by E. K. Regan, E. W. L. Nicol, Col. W. A. Bristow, H. Cerckel, Mrs. G. H. Miles, Dr. G. E. Foxwell, John Roberts, and Dr. E. W. Smith. 8vo. pp. 60. 1/-.

The State of the Atmosphere. "An Examination into the Effects of Atmospheric Pollution on Building Stones, etc., with a Preliminary Summary of the Conditions Disclosed by various Enquiries into the State of the Atmosphere of Great Britain," by Sir Frank Baines, K.C.V.O., C.B.E., F.R.I.B.A. An invaluable survey of the subject. Royal 8vo. pp. 36. 6d.

Home Fires Without Smoke. Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. Cloth-bound remainders, 6d.

The Smokeless Home. A popular 12-page illustrated pamphlet, with cover in colours, describing the ways and means for making the home smokeless. To be sold in quantities for general distribution. Single copies gratis. £5 per 1,000.

"Smoke Abatement and Fuel Economy in Steam Boiler Practice" (Published by the Manchester and District Regional Smoke Abatement Committee). pp. 11. 1d., post 2d.

N.S.A.S. Annual Reports. Gratis, by Post 1d.

PROCEEDINGS OF THE ANNUAL CONFERENCES. Each with all papers in full, and discussions. 8vo. Price 1/- each.

Newcastle, 1932. Presidential Address and papers on: "The Domestic Smoke Problem: the Possibilities of Coke-Oven Fuel"; "The Psychological Effects of Smoke"; "The Human Element: A Factor in Smoke Abatement."

Sheffield, 1933. Presidential Address and Resolutions, and papers on: "The Five-Years Clause and other Matters arising from the Public Helath (Smoke Abatement) Act, 1926"; "How the Citizen Takes the Air: The Personal Significance of the Smoke Problem"; "The Combating of Domestic Smoke in Industrial Areas."

Glasgow, 1934. Presidential Address and Resolutions, and papers on: "The Measurement of Atmospheric Pollution"; "The Effects of Smoke upon Visibility and Aviation"; "The Effects of a Smoke-Laden Atmosphere on Horticulture"; "Nature in Beautiful"; "Slum Clearance and the Smoke Problem."

Bristol, 1935. Presidential Address on "Barbarism," Resolutions, and Papers on: "The Sources of Atmospheric Pollution"; "Smokeless Equipment in Housing Schemes—Electrical, Gas, and for Solid Fuels"; "Smoke and the Countryside"; and "Dust and Grit Emission from a Sanitary Inspector's Viewpoint."

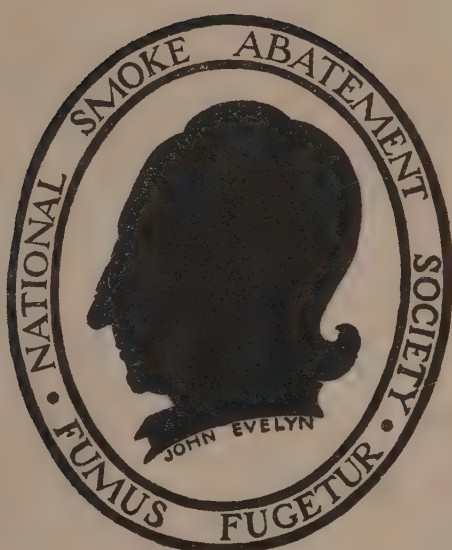
C 31

NATIONAL
SMOKE ABATEMENT SOCIETY
~~Charles House, Buckingham Gate,~~
Westminster, S.W.1.

*Palace
Charles
Bridge St.*

SMOKE ABATEMENT EXHIBITION

HANDBOOK AND GUIDE



SCIENCE MUSEUM, SOUTH KENSINGTON

(By permission of the Director, Col. E. E. B. Mackintosh, D.S.O.)

OCTOBER 1st to OCTOBER 31st, 1936

PRICE 6^D.

THE NATIONAL SMOKE ABATEMENT SOCIETY

The Society, as a voluntary organisation, depends for its continued activity upon the support of its members. Membership is open to all and is invited from all who desire to help to further the work for clean air and the benefits that it will bring.

Donations and legacies will be gratefully accepted.

Minimum annual subscription, which includes Quarterly Journal and other literature, 10s. 6d. Associate membership, 5s. Journal subscription, 2s. 6d. per annum (four issues).

Full particulars of the Society and its publications from the Exhibition bookstall, or on application to the General Secretary at 36, King Street, Manchester, 2.

The Society is supported by over 100 of the largest Local Authorities, representing more than one-third of the total population.

CONTENTS

	PAGE
FOREWORD. <i>By The Right Hon. Sir Kingsley Wood, M.P., Minister of Health</i>	4
A REVIEW OF THE SMOKE ABATEMENT MOVEMENT. <i>By H. A. des Vœux, M.D.</i>	5
THE LAW RELATING TO SMOKE. <i>By Charles Gandy, Barrister-at-Law</i>	7
SMOKE ABATEMENT AND LOCAL GOVERNMENT. <i>By John W. Beaumont, M.R.S.I.</i>	9
ATMOSPHERIC POLLUTION PRODUCED BY THE COMBUSTION OF COAL. <i>Contributed by The Department of Scientific and Industrial Research</i>	12
METHODS FOR THE MEASUREMENT OF ATMOSPHERIC POLLUTION BY SMOKE. <i>By J. S. Owens, M.D.</i>	15
SMOKE AND HEALTH. <i>By Lt.-Col. J. du F. Langrishe, D.S.O., M.B.</i> .	18
EFFECTS OF SMOKE AND ATMOSPHERIC DEPOSITS ON STONE. <i>By Arthur R. Warnes, F.I.C.</i>	21
THE EFFECTS OF SMOKE ON VEGETATION. <i>By Dr. A. G. Ruston</i> .	23
SMOKE AND AVIATION. <i>By Flight Lt. H. M. Schofield</i>	27
THE DOMESTIC SMOKE PROBLEM WITH SPECIAL REFERENCE TO NEW HOUSING ESTATES. <i>By Marion Fitzgerald, A.R.S.I.</i>	29
EFFICIENT INDUSTRIAL STEAM RAISING. <i>By G. W. Andrew</i>	33
THE PROBLEM IN OTHER COUNTRIES. <i>Communications from Correspondents Abroad</i>	38
DESCRIPTION OF EXHIBITS	46
ADVERTISERS' ANNOUNCEMENTS	64-78
INDEX TO ADVERTISEMENTS	79

FOREWORD

BY THE RT. HON. SIR KINGSLEY WOOD, M.P., MINISTER OF HEALTH

PROVISION is being made more and more to secure pure water, pure milk and pure food. But every day we breathe a quantity of air much greater in weight than the quantity of food and drink which we consume, and in a smoky atmosphere this air contains dust, soot, tar and acid. Modern research has demonstrated the value of sunshine in the promotion and maintenance of health, but smoke prevents the health-giving rays of the sun from reaching the homes and lives of our people. As Minister of Health I therefore welcome the efforts which the National Smoke Abatement Society are making for the purification of the atmosphere by educating and stimulating public opinion and by bringing together in their annual conferences the workers in local government and in industrial enterprise, those engaged in practical administration and those engaged in scientific research.

In promoting this Conference and Exhibition the Society are taking a further step to arouse the public conscience. The Exhibition will bring before the public eye the many aspects of the problem of atmospheric pollution and will be of particular interest in enabling comparison to be made between work done in this country and work done abroad.

I hope that the Exhibition will receive wide patronage and publicity.

KINGSLEY WOOD.

A REVIEW OF THE SMOKE ABATEMENT MOVEMENT

By H. A. DES VŒUX, M.D.

President, National Smoke Abatement Society

SIX hundred years ago saw the commencement of the burning of "sea cole" in London. The smoke and dirt was so strongly objected to that a Commission was set up to prevent the use of coal, and a man was hanged for this offence. But the increasing difficulty of obtaining wood made the burning of coal a necessity, and although there were many more protests we learn of little official interest in the problem until about 1840, when a Committee of the House of Commons reported that steps could be taken to diminish the smoke nuisance. The Public Health Act of 1875 was the first to contain general clauses dealing with smoke.

Mr. Ernest Hart, in 1885, organised an exhibition of smoke abatement appliances, but was forced to give up his efforts to diminish the nuisance owing to public and official apathy.

The Coal Smoke Abatement Society was formed in London, under the ægis of the late Sir William Richmond, R.A., to contest the smoke of London. On a meagre income of about £300 the Society started on its career of propaganda and some practical work, its first act being to appoint an Inspector, who reported fortnightly to the Committee the smoke nuisances which he discovered from the 1,000 premises "not being a private house" in and surrounding London. Black smoke emissions of ten minutes' duration in the hour were reported to the Health Authorities concerned, of which there were over thirty.

The Committee also conducted a series of tests of the open coal fire with regard to its efficiency as a producer of heat, both radiant and convected, and the amount of smoke emitted.

In order to influence public opinion Dr. J. S. Owens invented the first gauge for collecting and analysing the dirt which fell from the air in four different districts of London, and in 1912 the Atmospheric Pollution Committee was formed, under the chairmanship of Sir Napier Shaw, to continue and extend the measurement examination of the polluting elements. It is now a committee of the Department of Scientific and Industrial Research, and reports twice a year to a conference of local authorities and those who in other ways support the movement. An annual report is published as a Blue Book.

Several attempts were made to induce the Government to introduce a new Bill into Parliament, and in fact in 1914 Lord Newton did introduce a Bill in the House of Lords, which was rejected. Public opinion was at last becoming aroused to the seriousness of the evil, and in answer to the persistent outcry a Departmental Committee was appointed shortly before the war, but was unable to report until 1921. Five years had passed before

Mr. Neville Chamberlain, then Minister of Health, guided a new Bill through its stages in Parliament. The 1926 Act in many ways improved the position and enabled local authorities more easily to conduct their fight against owners of offending chimneys, and moreover made it clear to such people that it was almost useless to them to put up a fight when the authority was determined, so that as a result fewer cases came to court for decision, technical advice from a sanitary inspector and a statutory notice being usually sufficient. As a result of the Act the organisation of the smoke abatement movement has been strengthened by the formation of Regional Committees of Local Authorities. At present there is one Statutory Committee, which administers the law on behalf of its constituent authorities, and five Advisory Committees.

For many years representatives from the North had a seat in the Committee of the Coal Smoke Abatement Society, but owing to the difficulty of attendances a separate Society—the Smoke Abatement League of Great Britain—was formed, with headquarters in Manchester, and another in Glasgow, both of which were in constant communication with the London Society. An Annual Meeting of these societies was held in different centres, and converts to the gospel of cleanliness were slowly but steadily enrolled.

In 1929 the two English societies were finally united under the name of the National Smoke Abatement Society, with headquarters in Manchester (36, King Street) and an office in London (71, Eccleston Square). Sir Lawrence Chubb was the Secretary of the London Society after its first few years, and remained in that capacity until the amalgamation. As all his friends and admirers know, he did yeoman service to the Society and guided it through most of its most difficult and arduous times. Mr. Arnold Marsh was then appointed Secretary of the amalgamated Society, and has served with eminent ability and continued hard work.

The Society, after many years of neglect and opposition, is now recognised by all at its worth, and annually receives an invitation from municipal corporations to hold its conferences in their cities or towns. Such centres as Liverpool, Leicester, Glasgow, Sheffield, Newcastle and Bristol have already officially received the Society. This year we have been gratified to receive the permission of the Director of the Science Museum to organise this Exhibition, the success of which is mainly due to his staff and many co-operating Government Departments and national industrial associations.

Much has been achieved by the Society during the last thirty years, but much more remains to be done.

The atmosphere of all big towns is still horribly offensive, and until every inhabitant of these islands is convinced that such a state is a sign of ignorance and barbarism, we cannot expect that the atmosphere which we breathe is such as is fit for the perfect health of a nation.

THE LAW RELATING TO SMOKE

By CHARLES GANDY, Barrister-at-Law

Chairman, Executive Committee, National Smoke Abatement Society

LIBERTY in a civilised community depends on the observance of our obligations to one another. Such obligations, when publicly recognised and enforceable, are known as the law. No liberty is more important to human life than the enjoyment of unpolluted air and light, and the common law of this country has long regarded interference with such enjoyment as an actionable nuisance, if it is such as materially to interfere with the ordinary comfort of human existence. Such a nuisance may be either "private" or "public." If it only affects one individual, he may bring an action for damages and an injunction. If it affects only a few, each may bring such action, or they may join in bringing one. If it affects a considerable number it becomes a public nuisance, which may be the subject of an indictment for misdemeanour on the prosecution of an individual or of the local authority, but the usual procedure is an action.

The common law remedy against smoke or fumes on the ground of nuisance is available against offenders whether in business or industrial premises or in private dwelling-houses. It is, however, of little use save in exceptional cases, for though it is recorded that Queen Elizabeth found herself "greatly greved and anoyed with the taste and smoke of the sea-coales," which were then beginning to replace wood fuel, modern senses have become too fatally accustomed to an unwholesome atmosphere, and in judging the seriousness of a particular nuisance the court will not readily act in advance of public opinion.

Restrictions imposed by the legislature are on a different footing, and so far these relate only to premises other than private dwelling-houses. Laws for the protection of public health, in spite of the great volume of law now existing on almost every branch of this subject, are of comparatively recent origin, dating from a short Nuisances Removal Act in 1848. The use of coal had indeed been forbidden in London as prejudicial to health so long ago as in 1273, and in 1306 artificers were prohibited by Royal Proclamation from using "sea-coal" in their furnaces, one offender even suffering the death penalty. The Railway Clauses Consolidation Act, 1845, required locomotive steam engines to be so constructed as to consume their own smoke; and the Towns Improvement Clauses Act, 1847, and Acts of 1853 and 1856 for the metropolitan area, contained sections dealing with factory smoke. For practical purposes, however, the statutory law governing smoke emission is to be found in the Public Health Act of 1875, or for London in the Public Health (London) Act, 1891, as now amended by the Public Health (Smoke Abatement) Act, 1926. Under the Act of 1875 it is the duty of every local authority to

cause inspection of its district to be made periodically with a view to ascertaining nuisances calling for abatement under the Act, the provisions of which the authority is required to enforce in order to abate such nuisances. Every urban authority is also required to employ such officers as may be necessary for the efficient execution of the Act, under which valuable work is now done by Smoke and Sanitary Inspectors.

The powers of local authorities under the Act of 1875 and the Amending Act are not, however, extensive, and hardly touch the domestic smoke problem, now generally admitted to be the most serious, nor are they really effective in regard to smoke from offices and business, as opposed to industrial premises, although these play a large part in creating the objectionable atmosphere and dirty appearance of city centres. Authorities are, however, empowered by the Amending Act "to undertake or combine in undertaking investigations and researches into problems relating to atmospheric pollution and the abatement of smoke nuisances," and to contribute towards the cost of similar investigations and researches by others and, under the Public Health Act, 1925, to arrange for the publication of information on questions relating to health or disease, and for the delivery of lectures and the display of pictures in which such questions are dealt with. Little use has as yet been made of these powers, and the application by authorities of the law relating to smoke prevention has been so far mainly directed against the only nuisance which for practical purposes constitutes an offence under the Acts, viz. the "chimney (not being the chimney of a private dwelling-house) sending forth smoke in such quantity as to be a nuisance."

Under the Amending Act it is no longer necessary to prove as formerly that the smoke emitted is "black," a matter of difficulty if absolute black is meant, the worst smoke being often of a milder shade, and smoke is extended to include "soot, ash, grit, and gritty particles," various metallurgical and other processes being, however, at present exempted. For fixing a standard in regard to smoke authorities are empowered to make byelaws, though the only byelaws so far sanctioned are those providing that the emission of black smoke for a longer period than two (or in some cases three) minutes in each half-hour shall be deemed a nuisance. Authorities are given power to combine together for the carrying out of their duties under the Act, a power which ought to be welcomed especially by the smaller authorities, who apparently experience difficulty in paying a full-time Inspector.

(No reference has been made in the above to the Public Health Act, 1936, which does not come into operation until the 1st October, 1937. The Act, so far as it relates to smoke, is mainly a re-enactment of existing law, though it adds provision of possible importance enabling byelaws to be made regulating "stoves and other fittings in buildings (not being electric stoves or fittings)."

Further mention of the Act will be made in a forthcoming issue of the *Journal of the National Smoke Abatement Society*.—C. G.)

SMOKE ABATEMENT AND LOCAL GOVERNMENT

By JOHN W. BEAUMONT, M.R.S.I.

Chief Sanitary Inspector, Halifax

DURING the present century, and more especially in the post-War period, the work of local government in this country has increased to such an extent that it may now be regarded as a science, demanding the highest standard of efficiency and devotion to duty from its practitioners if it is to be successfully carried out.

One advantage of this form of government is that the elected representatives of local government are in closer touch with the people they represent than is possible in the case of elected members of the central Government, thus enabling them to appraise the value of the national legislation they must administer, and to point out any defects or deficiencies in same.

It is universally acknowledged that the greatest asset of any nation is the health and happiness of its people, a truth attested in this country by the finest code of sanitary laws ever devised by man. Of these laws, those dealing directly with the health of the people must be regarded as of first importance. Measures have been enacted to secure that the houses we live in shall be healthy, our food supplies pure and clean, water supplies unpolluted, whilst there are a host of others all designed with the same object in view, namely, the health and happiness of the people.

It is therefore somewhat surprising to find that of all essential things, the purity of the air we breathe should apparently have received the least attention. It is, of course, true that legislation has been passed with the object of preventing the pollution of the atmosphere, but such is altogether inadequate to achieve the desired effect. Although the emission of industrial smoke has, to some extent, been curtailed, it must be remembered that no restrictions whatever have been placed upon the emission of domestic smoke.

Why should this be so? Is the purity of the air we all must breathe—by weight seven times as much as the food and water we consume—of less importance, for instance, than the purity of the food we eat?

It is obvious, therefore, that public opinion in this country must be thoroughly aroused and made to realise the importance of this subject before any very great advance can be made. That this is not an easy task is fully realised by such bodies as the National Smoke Abatement Society, which has for many years been declaiming the evils of smoke. Several reasons might be given to explain why such efforts have not met with a greater measure of success. One reason is, of course, the fact that the dweller in rural areas where there is practically no smoke, can hardly be expected to wax indignant over the condition of the atmosphere in industrial districts where, it may be, there is little else than smoke. Again,

it would appear that the habitual resident in these industrial areas has become so accustomed to the black skies—and probably devitalised as a result—that he really sees nothing out of the ordinary in them, or if he does, believes such a state of affairs to be both inevitable and irremediable. Another—and perhaps most important—reason is, that the air we breathe is to many people a very abstract thing. If the difference between clean and polluted air could be demonstrated as readily and forcibly as the difference between a sound and an unsound piece of meat, it would have a great effect upon the public consciousness.

What further steps, therefore, should or could be taken to arouse a sense of smoke consciousness in the minds of the people in this country?

How can a local authority assist in this?

There are indeed many ways in which a local authority may assist in the creation of a smoke-consciousness in the minds of the people and at the same time take such action as will actually result in a diminution of the amount of smoke discharged in its area.

In the first place, let us consider for a moment the question of housing. Almost every local authority throughout the country is at present engaged upon its five-year slum clearance programme, and new houses for the occupation of erstwhile slum dwellers are being erected at a maximum rate. Is full use being made of present opportunities to erect smokeless houses and make a notable contribution towards the abolition of domestic smoke? It should be remembered that such opportunities may never recur to the same extent as at present, and certainly not during this generation. Do all housing committees, when considering plans for the erection of their own houses, take into account the various smokeless methods which may be adopted for the purpose of heating and cooking? The choice was never so great as at present. Gas, electricity, and various forms of solid smokeless fuel are probably available in most districts—certainly in urban areas—whilst appliances specially designed for the use of these fuels are both numerous and available. It is true that the question of cost should receive the most careful consideration in view of the fact that the future occupants of these houses are invariably people of most limited means. Hence it may easily be that in some areas the cost of one or other of these smokeless fuels is so prohibitive as to render its use impracticable. The whole point of this plea is, however, that in all cases alternative smokeless methods should be fully considered before any decision is arrived at.

The second point has reference to the various public institutions owned by a local authority such as hospitals, sanatoria, public libraries, baths, washhouses, general offices, etc. Is the question of heating these places smokelessly ever considered? Occasions do arise in connection with existing buildings when a proper consideration of the possibilities of making use of some type of smokeless fuel will be beneficial to the ratepayers' health and pocket, in addition to being good propaganda. Again, respecting any existing plant in which raw coal is burned, is proper care exercised to ensure that the stokers or other persons entrusted with the working of such plant possess even an elementary knowledge of

the laws of combustion? As facilities for acquiring this knowledge are to-day readily accessible, it is suggested that a local authority should set an example to the private employer by engaging only those men who possess this knowledge.

As previously suggested, public opinion is largely moulded by skilful propaganda. In this connection a local authority has unique opportunities, and may commence its campaign with the knowledge that it is specifically empowered to carry out such work by Section 67 of the Public Health Act, 1925.

In addition to any local propaganda which may be undertaken, a local authority should wholeheartedly support similar work carried out by other—especially voluntary—bodies which greatly need encouragement and assistance. It will take its proper place in encouraging scientific research in regard to all forms of atmospheric pollution by joining up with other local authorities who are already supporting the work carried out by the Department of Scientific and Industrial Research in that connection. This will probably result in the installation in their own area of various appliances designed with a view to measuring the amount and nature of the pollution in the atmosphere, together with its effect upon the value of the sunlight and ordinary daylight. By so doing, the authority will not only be adding to the sum total of knowledge upon the subject, but will be enabled to compare its own atmospheric pollution with that of other and similar areas, and in its own area will be able to ascertain the extent of any improvement in atmospheric conditions. Such work has also its own propaganda value if the local authority will make use of it.

The Public Health (Smoke Abatement) Act of 1926 encourages the formation of Regional Committees—either advisory or statutory—to consider the problems associated with atmospheric pollution. Every local authority within the area of such a committee should be an active member of same, and if such a committee has not yet been established in its area, the local authority desirous of making its contribution to the cause of smoke abatement might take the first step necessary to its formation by convening a meeting of local authorities to consider the matter.

These are only a few of the activities which may be undertaken by any and every local authority, which will of themselves do something to arouse public opinion from its present apathy. If these activities are supplemented by well organised propaganda, including the holding of smoke abatement exhibitions, etc., their value will be greatly enhanced.

ATMOSPHERIC POLLUTION PRODUCED BY THE COMBUSTION OF COAL

Contributed by the Department of Scientific and Industrial Research

THE composition of coal varies through wide limits, but the chief constituents are carbon, hydrogen, oxygen, sulphur, nitrogen and ash. The combustion consists essentially of an oxidation process in which the carbon, hydrogen and sulphur unite with the oxygen of the air, producing carbon dioxide, water and sulphur dioxide respectively. If combustion of this nature were perfect, the only solid produced during the process would be the ash which, theoretically, remains on the grate—although, as will be shown, even under this condition some of the ash passes into the atmosphere.

Apart from this, complete combustion, which liberates the maximum quantity of heat, should not produce any *solid* atmospheric pollution. Of the *gases* produced, the sulphur dioxide is the only one which need be regarded as noxious. This is an inherent characteristic of coal burning, and changes in the conditions under which the fuel is consumed have little effect on the quantity of this gas produced. In certain cases, for example, in the latest modern power stations, the major part of the sulphur of the flue gases is removed by suitable treatment and only a very small quantity is emitted. The average sulphur content of British coals is about 1.5 per cent., corresponding to an emission of 67 lb. of sulphur dioxide per ton of coal burned. In the case of Battersea Power Station this has been reduced to 4.4 lb. per ton.

While the emission of sulphur dioxide is independent of the conditions of burning, the presence of solid matter in the flue gases definitely points to inefficient combustion. One of the chief difficulties in burning coal is the enormous volume of air which has to be brought into contact with the fuel. Roughly a ton of coal occupies about 27 cu. ft., but owing to the dilution of the oxygen in the atmosphere by four times its volume of nitrogen some 300,000 cu. ft. of air must be supplied to the coal. In practice it is found that complete oxidation is not obtained if only the theoretical air requirements are used, and normally an air supply 25 per cent. in excess is found to give the best results.

To understand the production of smoke it is necessary to divide the coal into volatile matter, fixed carbon and ash. When the coal is introduced into the hot furnace, the volatile matter is first distilled off, leaving behind the fixed carbon and ash in the form of coke. The volatile matter itself, which is composed of tarry acids and various hydrocarbons, mixes with the air supply. The subsequent history of the mixture depends on two factors, the oxygen supply and the temperature of the combustion space.

If the conditions are suitable, i.e. if there is an ample supply of oxygen and the temperature of the combustion chamber is sufficiently high, the volatile matter is completely oxidised and no solid matter is given off. Certain of the hydrocarbons, however, are difficult to ignite, for example, methane, and these may not take part in the combustion and a small amount will pass into the atmosphere. If the temperature is too low some of the volatile matter will not be ignited and the tar passes into the air as visible pollution. An insufficient air supply leads to a partial combustion of the tar and hydrocarbons in which free carbon is produced. The same condition is obtained if the air is not mixed with the volatile matter or not uniformly supplied to the fuel bed so that parts are deficient in oxygen. Again if the burning mixture is cooled by a cold air supply the chemical action is suppressed and free carbon produced.

The coke left on the fuel bed burns, without the production of any solid matter, to carbon dioxide, leaving the ash. Of this a large part is retained on the grate but some is carried by the air currents up the stack. Here again, if the air supply is low, some of the coke burns to carbon monoxide instead of dioxide with an attendant loss of heat.

Thus the solid matter emitted by a chimney consists of carbon, tar and ash, but as well as these, it is found that certain water soluble products, such as chloride and sulphate of ammonia, are also present, these substances being derived from the original coal.

In modern industrial practice the combustion engineer has control of the supply and distribution of air to the fuel bed and the steady conditions which obtain in a furnace allow efficient combustion to be maintained. In practice it is advisable to run the installation with a faint haze over the mouth of the chimney, black smoke emission corresponding to loss of energy resulting from unburned products passing into the atmosphere, while no visible smoke emission is associated with an air supply greatly in excess of requirements and is accompanied by a loss through the heated gases passing away up the flue.

The mechanism of smoke production in an open domestic grate burning raw coal is very similar to that just described, but it differs in two important factors. Firstly the air supply to the fire cannot be controlled completely, and secondly, in the life of the average domestic fire, the temperature conditions in the grate vary through a wide range. Thus, in the ignition stages of the fire, the volatile matter passes into the space above the fuel and, as this space is cold, a little tar passes unchanged into the atmosphere. As the fire increases in intensity the space above the fuel increases in temperature until it is high enough to ignite the volatile matter. At this stage flames break out. The heated gases coming from the burning fuel form only a small part of the gases passing up the flue, for the products of combustion are diluted by 10 to 20 times their volume with fresh air which enters at the face of the fire, but does not come into contact with the hot fuel. This influx of cold air cools the burning mixture at the back of the grate below its ignition temperature and combustion may be depressed. The action may often be seen in the case of flames, which are luminous

as a result of the presence of incandescent particles of carbon, but end in a "smoky" tip when the carbon has been cooled to a temperature too low to emit visible light. A similar cycle takes place when a fresh charge of coal is placed on a dying fire, the space above the fire losing heat as the radiation from the fire is cut off by the upper layer of fresh coal. Thus a distillation smoke is first produced changing to one containing a much greater proportion of carbon when flames break out.

In industrial work the solid pollution per ton of the fuel consumed may range from 10 lb. up to 40 or 50 lb., depending on various factors, including the composition and properties of the coal employed, the type of boiler and the efficiency with which the plant is run. The lower figure would correspond roughly to a light haze over the chimney stack, denoting efficient management of the installation, and the upper limit would correspond to a fairly dense smoke emission. The factors controlling the combustion of coal in an open grate vary through an enormous range, for the coal fire relies on natural draught to support combustion. Thus the draught will depend not only on the cross-section of the flue and its height but also on the internal and external temperatures.

As a result of recent work it is now possible to examine in more detail the smoke emission from a domestic fire. If a beam of light is passed through a column of smoke, the intensity of the emergent light is reduced, and it has been found that the amount by which the beam of light is cut down depends on the weights of solids contained in unit volume of the smoke. This measurement, together with the volume of gases passing up the flue allows the rate of smoke emission to be determined at any one moment and its variation to be followed throughout the life of the fire. Certain important facts have been revealed. For example, if flames break out owing to the burning up of the fire or stirring it, the smoke emission is increased. Again, different coals produce different types of smoke. Some coals produce mainly carbon smokes while with others the percentage of tarry matter is high. This shows that the volatile matter passes into the atmosphere without change over a much longer period, probably owing to the ignition temperature of the volatile matter being higher or to a lower temperature being set up by the burning coal.

The domestic fire reaches a stage when the major part of the volatile matter has been distilled off and then the fire burns smokelessly. The fuel then consists virtually of a low temperature coke and the solid emission consists mainly of ash carried away by the flue gases. As the temperature and draught produced by a coke fire are much less than those associated with a coal fire, the quantity of ash carried away will be less for a coke fire than a coal fire.

The problem of the pollution of the atmosphere by the burning of coal is being studied at the Fuel Research Station of the Department of Scientific and Industrial Research at Greenwich. The scope of the investigation is indicated in the above notes and the work is carried out in co-operation with the Coal Utilisation Council, who are contributing towards its cost.

METHODS FOR THE MEASUREMENT OF ATMOSPHERIC POLLUTION BY SMOKE

By Dr. J. S. OWENS

FOR purposes of measurement the pollution of the air may be divided into two broad divisions. First, the solid or liquid matter such as soot or tar, and second, gaseous impurities such as sulphur dioxide.

The methods of obtaining some measure of the degree of pollution by these two classes of impurity will obviously be different. In what follows the methods described are those adopted as standard in the Investigation of Atmospheric Pollution in this country. This does not mean that there are no others, or that they could not be modified, but simply that these are the methods now adopted. We will separate these two broad divisions for purposes of description.

SOLID OR LIQUID IMPURITY

The soot emitted by chimneys is the solid we are mainly concerned with, and the liquid is the condensed tar vapours of bituminous coal emitted in the early stages of combustion.

This type of pollution was subdivided for purposes of measurement into deposited and suspended matter. There is no really strict line of demarcation between these two, as the deposited matter was suspended at some time and the suspended matter would presumably be deposited in course of time. The division was, however, found a convenient one and the methods evolved took account of this.

The Measurement of Deposit.—A good deal of experimental work was done in finding some means of measuring deposit from the air. The final form of the “standard deposit gauge,” which is now adopted, consists of an open-topped glass bowl of about 30 cms. diameter with vertical sides and sloping bottom; the latter has a central hole with a projecting spigot to which a rubber tube can be attached, to carry the deposited matter to a bottle placed underneath. The gauge vessel is supported in a galvanised iron ring at about 4 feet above ground level and the ring is mounted on a three-legged stand. The vessel itself is surrounded at a distance of about 6 inches by a wire screen, partly to protect it from injury and partly to prevent artificial pollution by birds. These “standard deposit gauges” are set up by co-operating authorities who wish to measure the amount of impurity deposited in their area, and a site is selected as free as possible from abnormal impurity. One of the greatest difficulties is to get a site protected against interference. The aim is also to place these gauges upon the ground, but in many cases where this is not possible, they are fixed upon the roofs of buildings.

The gauge is exposed for one month and the rainwater and deposit caught are removed in the bottle fixed below the gauge, a fresh one being placed in position instead. Prior to removing the bottle, the gauge is washed down with some of the liquid already collected in order to remove adherent deposit.

The liquid containing the deposited impurity is next analysed, usually by the City Analyst, and the impurities contained are divided into two groups, the soluble and the insoluble matter, the sum of the two being the total deposit. Insoluble impurity is divided into tar, carbonaceous matter and ash, while the soluble matter is divided into loss on ignition and ash.

A further estimation is made of the sulphates, chlorides and ammonia present in the soluble part of the deposit.

The results thus obtained are set down in a blank form, provided by the D.S.I.R., which is responsible for the management of the Investigation, and returned to the office of the Superintendent of Observations, where all results are collected and analysed, and an Annual Report prepared on them. During last year there were in operation 115 such deposit gauge stations, and the deposit at these ranged from something under 100 tons to nearly 700 tons per square mile per annum.

Suspended Matter.—The examination of the suspended part of the impurity is carried out by a method of filtration through white paper; an automatic instrument is used for doing this. Briefly, the instrument filters two litres of air through a disc of filter paper $\frac{1}{8}$ inch in diameter, and it does this automatically about two to four times per hour. The discoloration left on the paper, due to the sooty matter in the air, permits an easy estimation to be made of the amount suspended in the air at the time of filtration. The estimation is done by passing the filter paper, with its small $\frac{1}{8}$ -inch diameter record, under a scale of shades, when viewed through this central hole and moved about until a shade is found which matches it; the amount of impurity is read directly from the scale. Such a scale, has, of course, to be previously calibrated to determine the value of the unit. The shade numbers range from 1 to 20, but it is unusual to have shades over No. 6, although in thick city smoke-fogs shade 20 is occasionally reached, but only very rarely.

One of the forms of the instrument is operated by water, so that when connected up to a water tap it automatically commences to take records of the impurity in the air, and all that is necessary is to renew the disc of filter paper once every 24 hours.

This instrument gives very valuable information, and of a form not previously available. For example, it is now known that the smoke pollution of cities obeys a very regular law as to its distribution. The cleanest air is found early in the morning from about midnight to 6 a.m., after which the impurity rises rapidly to a maximum in the forenoon about 9 to 11 a.m., and then falls again, but rises later to make a second maximum about 7 to 8 in the evening. With slight variations this is true of practically all the cities where records have been taken.

The method in its present form was designed to record black impurity only, that is, the sooty smoke of the cities.

GASEOUS IMPURITY

Concentration of Sulphur Gases.—The chief impurity we have to deal with is sulphur gases from the combustion of coal containing sulphur. It is well known that the sulphur gases are highly in-

jurious to health, vegetation and to buildings, hence a measurement to indicate the degree of concentration was considered advisable, and the method adopted is based on the aspiration of a measured volume of air through an absorption vessel containing an aqueous solution of hydrogen peroxide. The air has to be drawn through the apparatus by some form of pump, either electrically driven or by an ordinary water-operated filter pump. The air is measured by passing through a gas meter after the absorption of the sulphur dioxide. The pump is run for 24 hours, and set to draw about 50 to 100 cubic feet, and the amount of sulphur dioxide absorbed is obtained by titration of the liquid with an indicator. The result is calculated to parts per million by volume and a form containing the monthly figures for each month is sent to the office of the Superintendent of Observations.

In this way results were obtained last year from 11 different cities, and the concentrations found ranged from 0.154 p.p.m. in London to 0.0626 in Kingston-upon-Hull, based upon the average of a month's observations. This measure of sulphur is one of concentration and it does not follow that the attack upon buildings, vegetation and so on is governed by concentration alone. The method gives an average for each 24 hours, and during this period there has in all probability been considerable variation in the concentration, hence a method of obtaining hourly concentrations is now under examination.

Measurement of Active Sulphur.—There are many factors, such as wind velocity, humidity, and so on, which, in addition to the concentration, may affect the attack of sulphur on buildings. A second method has, therefore, been adopted which gives a direct measure of the sulphur attack, and this is known as the "lead peroxide" method. A small porcelain cylinder about 6 inches high and an inch in diameter has some fabric wrapped round it to act as a bond for a paste of lead peroxide, which is worked into the fabric and smoothed off, leaving a clean smooth outer surface on the cylinder. Lead peroxide when exposed to sulphur dioxide reacts with it to form sulphate of lead, thus $\text{PbO}_2 + \text{SO}_2 = \text{PbSO}_4$. Such a cylinder is mounted in a stand and exposed to the air for a month at the place where it is desired to take a measurement. The cylinder is protected from rain by a small roof and at the end of a month it is found that a certain amount of the lead peroxide has been converted into lead sulphate and the amount so converted is a measure of the activity of the sulphur. In considering the method it must be realised that it is not a measure of concentration alone, but rather of the activity of the sulphur in its attack upon surfaces which are susceptible to it. By weighing the amount of sulphate formed, the figures can be calculated to a value of SO_3 per 100 cm.² of surface per day of exposure, and this is the final form in which the measure of active sulphur is recorded.

During last year there were 42 such stations operating the lead peroxide method, and the highest degree of sulphur activity was found at the London County Hall, Westminster Bridge, with a monthly average of 5.05 milligrams per 100 cm.² per day. The lowest monthly average was at Lymington, Hants, with 0.199 milligrams.

SMOKE AND HEALTH

LT.-COL. J. DU F. LANGRISHE, D.S.O., M.B., D.P.H.

Lecturer in Public Health, Edinburgh University

AIR, THE ESSENTIAL OF LIFE

OF all the elements that sustain life, air is the most important. In round figures, without food we die in three weeks ; without water we die in three days ; but without air we die in three minutes. Furthermore, the average person inhales in 24 hours about 516 cu. ft. of air, weighing $38\frac{1}{2}$ lb. ; he also consumes in that time about 7 lb. of solid food and liquids : therefore he consumes five and a half times by weight more air than food and water combined. Obviously, therefore, air is of far greater importance to man than either his food or his liquor.

DIRECT EFFECTS

It has been well known for many years that the lungs of town-dwellers are marked throughout by dark mottled patches, due to the continued inhalation of smoke-laden air, and that the glands which drain the lymph from the lungs are largely filled with masses of carbon particles. Along with these there are inhaled other constituents and accompaniments of smoke, such as tar, acids and grit—all of them irritative, and some destructive, agents.

Those of us who reside in, or frequent, our large cities and towns will call to mind the extremely unpleasant effects caused by breathing dense smoke-fog—the coughing, and even the choking sensations, which it causes. These are entirely due to the tar and acids which are then present in high concentration. Two striking illustrations can be given of the devastating effects of such conditions when prolonged. Thus, in Glasgow, in November and December, 1909, during a series of bad smoke-fogs the death-rate from respiratory diseases rose from 2·1 per 1,000 population (just before the fog period) to 13·9, while in the fog-free towns in the neighbourhood the death-rate from these causes increased from 1·5 to merely 4·8 per 1,000. The other illustration comes from the Meuse valley in Belgium where, in December, 1930, as a result of three days' concentration of smoke-fog 65 persons and many cattle perished under very distressing circumstances.

The causes underlying the high mortality from respiratory diseases amongst town-dwellers must operate continuously on their health, and such effects are found to be most marked at the extremes of life. Thus, owing to the devitalising of the delicate tissues by the irritating matters in smoke, the death-rate of infants in towns from these diseases is 16·3 per 1,000 births, as against only 8·8 in the case of children reared in the country. At the other extreme of life we find that the death-rate from these diseases amongst

those aged 65 and upwards is 11·4 per cent. greater in the townsfolk than in the rural population, while the associated death-rate from heart disease shows an almost exactly similar increase of 10·4 per cent.

The tarry and sulphur acids in smoke, less visible but more dangerous than the carbon, set up an irritation in the mucous lining of the wind-pipe and smaller tubes. Continued irritation is followed by chronic catarrh, especially in the elderly. This leads to gradual loss of elasticity in the lung tissue, with ultimate loss of function and disappearance of many of the air-cells and their fine network of blood-vessels. The blood is no longer properly oxygenated and consequently increased strain is thrown upon the heart, which may then fail.

The Pathologist to the London Zoological Society in a recent Report states : “ Among birds that have lived for some years in the aviaries fatal necrosis (death) of the lung localised around carbon deposits causes many deaths : such necrotic foci in the lung are frequently colonised by tubercle bacilli which rapidly become disseminated, with fatal results.” A similar association of tubercle bacilli with tissue damage, probably by inhaled grit, has been noted in human lung tuberculosis. An investigation recently carried out in Liverpool has aroused a strong suspicion that inhalation of the tarry matter in the atmosphere is at least partly responsible for causing cancer of the lung.

INDIRECT EFFECTS

The indirect effects upon health arise in two ways—firstly, by the cutting-off of solar radiation and sky-shine and, secondly, through the action on vegetation. The smoke-blanket cuts off the radiations in proportion to its density and thickness, those which are reduced most being the radiations of greatest importance, namely the “ vital ” ultra-violets which by “ activating ” the formation of vitamin D in the skin enable the body to utilise fully the calcium and phosphorus in our foodstuffs and so form good bone and sound teeth. Hence, the reduction of these radiations causes stunting of growth and tends to the production of rickets and decay of teeth. The lower weights of urban children as compared with rural are indicative of this effect : thus it has been found that at ages two and four years the former weigh less than the latter by 3·3 and 4·1 lb. respectively.

At the same time we may note the pallor of town dwellers, also attributable to this deprivation of sunshine. There follow, further, poor health and lowered resistance to infection, especially respiratory : therefore it is not surprising that tuberculosis of the lung and many of the infectious diseases are rampant in our large cities and towns.

Psychological ill-effects are inter-related with the physiological : smoke-gloom lessens the working-power, potential reserve and well-being of the individual ; it increases fatigue, irritability and restlessness ; gloom without makes for gloom within and induces mental depression.

ACTION ON PLANT LIFE

By reason of its action on plant life, smoke exerts a secondary, yet highly important, influence on human health. The mode of action includes—reduction of sunlight; accumulation of sooty deposit closing the minute pores; lodgment of acids on foliage and growing-points which, in consequence, are burnt and killed, covering the surface of the soil with a deposit of soot to such an extent as to hinder the free passage of air to the roots. Furthermore, soil untilled for some time accumulates acid from the deposit and so becomes “sour,” with the result that the lime-content may be noticeably reduced, so that the stunted crops are, in turn, deficient in lime. It has been shown that pasturage in the neighbourhood of the industrial towns in Lancashire and Yorkshire, which 30 years ago supported two beasts to the acre, can now scarce carry one beast to three acres: the milk from such cows must necessarily be deficient in calcium and in the essential vitamins which can only be formed by adequate sunlight. This is a very serious thing for children, especially the very young, whose diet consists so largely of milk; for if their food be deficient in these respects, then not only is their health affected and growth retarded but, worse still, they are liable to suffer from rickets and caries of their teeth. It is highly probable that herein lies the explanation of the one-time widespread existence of decayed teeth among the inhabitants of the industrial towns of Lancashire.

Finally, there is the effect on vegetables grown in town garden-allotments. Lettuces, for instance, grown under the pall of smoke give only 30 per cent. of their normal yield and are similarly lacking in essential constituents. The allotment-holder is thus deprived of a large part of the fruits of his toil, while both he and his family lose much of the benefit that they should derive from the consumption of fresh vegetables.

EFFECTS OF SMOKE AND ATMOSPHERIC DEPOSITS ON STONE

By ARTHUR R. WARNES, F.I.C., A.Inst.P., M.I.Chem.E.,
M.I.Struct.E.

SOOT contributes to the surface discoloration and deeper staining of stonework, and it also plays a more or less active part in the process of decay. Speaking broadly on the matter of discoloration and decay by soot, the sandstones suffer more from surface discoloration and less from decay than the limestones.

In order to make clear how it is that soot causes these troubles it will be necessary to consider, at least briefly, the composition of soot. This varies a good deal according to whether it is produced by burning coal in domestic fire-grates, or coal or oil fuel under factory boilers.

It must be borne in mind that soot is not pure carbon ; it contains varying amounts of tar, ammonium chloride and ammonium sulphate, and often free sulphuric acid, and it is to these four ingredients that much of the trouble caused by soot, so far as building stones are concerned, is due.

The percentage of tar varies between 0·10 per cent. and 40 per cent. ; that of ammonium chloride, 1·0 per cent. and 8·0 per cent. ; that of ammonium sulphate, 3·5 per cent. and 8·0 per cent. ; and that of sulphuric acid 0·25 per cent. and 7·0 per cent.

It should be noted that approximately 96 per cent. of the nitrogen in soot exists as compounds or salts of ammonia, and it is to these salts that the main manurial value of soot depends.

Soot, owing to the presence of tar, is of a somewhat sticky nature, and this stickiness is sufficiently pronounced to enable it to stick even to such smooth surfaces as glass. It will, therefore, adhere more or less easily to those stones used in buildings which have a smooth polished surface such as the granites and marbles, and thus discolour them. Stones with rough surfaces, such as many of the limestones and most of the sandstones, will offer much easier means of attachment, the soot filling the tiny cavities or pores on the surface.

After the lapse of several years much of the sooty matter becomes more or less fixed to the surface of the stone. This is due to the entanglement of the soot by crystals of sulphate of lime, a by-product of decay, and results in the formation of a dark brown to almost black layer on the surface of a limestone, and in the case of certain sandstones almost entirely around the individual sand grains on the surface. This coating is for all practical purposes insoluble in water.

From the point of view of discoloration, the action of soot varies somewhat. In the case of the granites it produces almost entirely, if not entirely, a discoloration due to adherence of the sticky black matter to the surface of the stone. In the case of sandstones, after

exposure for some years very large areas become uniformly discoloured, almost black, and sometimes the stones are stained to about $\frac{1}{8}$ inch beneath the surface. With reference to the limestones and marbles, areas of these are stained irregularly and often the stain becomes deep seated. The chief reason of the irregularity of the staining of the limestones is the action of rain water which in the more exposed positions will wash away the soot which settles on the surface before it has time to become strongly attached. The processes connected with the action of rain water and those which are involved in the strong adherence of sooty matter to sandstone are more or less complicated and the general reader need not be bothered with them.

Dealing with the subject of the assistance which soot offers to decay, in the case of the granites, this may be considered as negligible. In regard to the sandstones, some of these are affected very materially by the action of the sulphuric acid and ammonium salts which soot contains, but others are not acted upon to any very great extent. It is only those sandstones which have as the natural binding material for the sand grains, a fairly high percentage of magnesium and calcium carbonates. In regard to the limestones and marbles (which latter are physically changed limestones but are still chemically similar) the action of the sulphuric acid and its ammonium salt is much more marked and in many cases bad erosion or other type of decay is produced. The limestones and marbles are composed almost entirely of carbonate of lime or calcium carbonate. Much of the intensity of the decay will depend upon the positions of the stones in the building, their physical properties, particularly that property which is known as capillary action, and the orientation of the elevation which the stones are in.

THE EFFECTS OF SMOKE ON VEGETATION

Dr. A. G. RUSTON

Late Lecturer and Advisory Economist at Leeds University

WHILE it may be difficult to obtain trustworthy data as to the effects of smoke on public health, on account of the great differences in the occupations followed in town and country, there can be no question as to the injurious effects of a smoke-laden atmosphere on vegetation.

In this respect it will act in various ways.

(a) *The smoke cloud will limit the available sunshine.*

The sunshine records, as taken by the ordinary sunshine recorders, show that there is a difference of more than 17 per cent. in the yearly average number of hours of bright sunshine in the centre of Leeds and the purer atmosphere of Adel, some four miles to the north. When the actual intensity of the light is measured by a method devised by Professor Cohen, it is seen that the smoke cloud over the centre of Leeds shuts off not 17, but 40 per cent. of the actual light.

The energy of sunlight is required by the green leaf for the conversion of carbon dioxide into carbohydrates, and when 40 per cent. of that energy is cut off by the smoke cloud, the effective growth of the plant must be very effectively checked, as is only too obvious in the stunted vegetation which still survives in the badly polluted areas.

The following particulars with reference to the maximum growth of aucubas in different parts of Leeds are striking and instructive.

District.	Position.	Annual deposit in tons per sq. mile.		Maximum height of aucuba found in District.
		Total solid deposit.	Sulphur compounds as SO ₃ .	
Weetwood Lane ..	3 miles to N.	42	28	10 ft. 6 in.
Headingley ..	2 „ to N.	78	33	7 ft. 2 in.
University ..	1 mile to N.	114	38	5 ft. 8 in.
Park Square ..	Centre of City	243	56	3 ft. 2 in.
Hunslet ..	Industrial area	539	96	2 ft. 0 in.

(b) *The tarry matter coating over the leaves will tend to check if not prevent the natural process of transpiration and assimilation.*

A microscopic examination of the leaf will reveal the fact that when plants have been grown in a smoke-polluted atmosphere more or less of the stomatal openings will be choked with a tarry

deposit. This will be particularly noticeable in the case of evergreens, the leaves of which have to withstand the winter smoke, and most especially in the case of conifers—trees which are xerophytic, possessing small leaf surface and sunk stomata. The leaves from a juniper grown at Garforth, six miles from Leeds, but well in the drift of the smoke from Hunslet, were found to possess 75 per cent. of the stomatal openings more or less choked in this way.

Many of the evergreens in a smoke-infested area are quickly killed ; others first become deciduous and finally disappear. The behaviour of the privet in this respect is interesting.

District.	Deposit on leaves expressed in mgms. per sq. metre.	Observations with regard to Privet.
3 miles to the north of Leeds	158	Evergreen and flowers.
2 „ „ „ „ „	386	Evergreen but does not flower.
1 mile „ „ „ „ „	718	Few leaves only re- tained during winter.
Centre of the City	1264	Leaves fall in January.
Industrial Leeds.. ..	1620	Leaves fall in November.

While we may notice casually the fact that smoke pollution means stunted growth, it is possible to get a measure of the relative growth of plants where the conditions other than atmospheric conditions are the same. In the laboratory, the relative growth has been measured by estimating the amount of carbon dioxide assimilated by a unit area of leaf in a unit of time.

Plants whose leaves are possessed of a crinkled, hairy surface, thus easily catching the soot, and of a thin cuticle, readily damaged by the acid rain, are particularly sensitive to smoke pollution. On the other hand, those possessing a hard, smooth, leathery type of leaf with thick epidermis, like many of the alpiners, pinks, carnations, auriculas, London Pride and iris, are particularly resistant. Thus the primrose does badly in Hunslet, makes little or no growth, rarely flowers, and never lives through more than one winter, while the auricula is as hardy as possible, and not only lives but thrives, grows and spreads. The geranium can be grown in a smoke-infested area, but the calceolaria is always a failure. Perhaps no plant of this type gives a better indication of the amount of smoke pollution than the hollyhock. Eight hollyhocks, all propagated from the same parent plant, were planted in tubs containing soil taken from the same field of the Experimental Farm at Garforth. The tubs were then placed two at each station, in four different parts of Leeds. At only one station, that farthest north, did they flower the first year. In the second year, more than eight feet of growth was made at Adel, four miles to the north, while in the industrial area of Hunslet one plant only survived, a wizened, flowerless specimen, nine inches high.

- (c) *The presence of free acids in the smoke-polluted air will tend generally to lower the vitality of the plant.*

There is another source of injury to vegetation arising from the burning of coal, namely the sulphur acids brought down by the rain or present in the soot.

The deposition of acid along with soot upon the leaves of plants is probably one of the main causes of the early withering which is so characteristic of many forms of town vegetation. Thus ash trees in the purer parts of Leeds will retain their leaves six weeks longer than those grown in the more contaminated districts.

If, therefore, we look upon the leaf as the factory of the plant, we find that owing to smoke pollution the factory is actually closed down for six weeks out of the four months of its working year, while during the remainder of the time, as our assimilation experiments show, it will be working at less than half its normal pressure.

This loss of vitality is shown in a large number of ways.

(i) *Loss of power to produce colour.* Flowers grown in each case from plants propagated from the same parent plant were analysed by means of a Lovibond's tintometer after being grown in similar soil placed in different localities.

Bronze flowers in a smoke-infested district tend to run to yellow.

Red and blue tints are depreciated: the longer a plant remains in a smoky atmosphere the more it loses the power of producing colour. Evidently it is not simply a case of mere bleaching, but a radical change in the composition of the plant.

(ii) *Lowering of reproductive powers of plants.* This loss of vitality is also shown in a diminution of the reproductive powers of the plant, whether propagated from seed or from cuttings.

(a) The following table gives the germination capacity of *oats* grown at the stations indicated.

Station.	Annual deposit in tons per sq. mile.	Germination capacity (10 days).
Adel	29	98 per cent.
Headingley	78	92 per cent.
University	114	64 per cent.
Hunslet	539	17 per cent.

(b) One hundred viola cuttings taken from plants grown in Roundhay (annual deposit 26 tons per square mile) were struck in Hunslet and 98 per cent. grew. One hundred viola cuttings taken from plants grown in Hunslet were struck in Hunslet, and not one survived.

(c) It is shown by the inability of the plant to put up a fight against adverse conditions, as, for example, the winter frosts. To test this point, nine cabbage plants were planted out in the autumn at the five stations mentioned.

Station.	Annual Deposit, tons per sq. mile.	Observation.
Weetwood Lane ..	42	8 out of 9 survived the winter.
Headingley ..	78	2 out of 9 survived the winter.
University ..	114	6 dead by Christmas ; all by February.
Park Square ..	243	All dead by end of November.
Hunslet	539	All dead by end of October.

(d) *The effect of smoke pollution is cumulative, through the action of the acid rain upon the soil, in depleting it of lime, limiting the action of the all-important soil organisms, and checking root development.*

To test this, soil taken from the same field was placed in tubs at five stations, the relative purity of the atmosphere of which had previously been determined, and five successive crops—radishes, lettuce, wallflowers, winter cabbage and spring cabbage—grown. As can be seen from the following table, the results indicate a fairly close correlation between the relative degree of purity of the atmosphere in the neighbourhood of the stations as previously assessed, and the active amount of plant growth obtainable. Striking evidence as to the cumulative effects of smoke contamination was obtained, as the differences became more marked each year.

Station.	Relative purity of air as measured by freedom from sulphur.	Relative weight of crop (Station 5 = 100).		
		First crop Radishes.	Second crop Lettuce.	Fifth crop Cabbage.
1. Hunslet	34	46	31	15
2. Park Square	37	49	40	37
3. University	55	60	74	89
4. Headingley	70	90	86	122
5. Weetwood	100	100	100	100

It was interesting at the close of the vegetation tests, after the soil—all originally drawn from the same bulk—had been exposed at each centre for three years, to compare the effects of the varying atmospheric impurities upon the soil itself, more especially with regard to its content of calcium carbonate and bacterial flora. The results indicate clearly that the detrimental effect of the smoke-polluted atmosphere upon plant life is due partly to unfavourable changes in the soil, such as the steady depletion of the stock of calcium carbonate and the inhibition of the soil organisms, particularly the all-important nitrifying ones ; for while the activity of the ammonia-producing organisms was cut down by roughly 40 per cent., the activity of the nitrifying organisms was cut down by more than 85 per cent. Under these conditions the importance of frequent applications of lime both to farm and garden crops grown in an industrial area can scarcely be over-emphasised.

SMOKE AND AVIATION

By FLIGHT LIEUT. H. M. SCHOFIELD

AS I write, through my office window I see a sight which depresses me beyond belief. Here, on one of London's principal aerodromes, in 1936, at three o'clock in the afternoon, the hangars are closed.

An air of masterly inactivity exists. The bustle of aircraft and attendants, the training of Air Force Reservists, instruction of private and commercial pilots, testing, research, and the dozen and one other aerial activities one would expect to see, are brought to a standstill. The reason? An east wind bringing the smoke from London and causing this beastly grey pall which has reduced visibility to less than five hundred yards and washed-out flying for the rest of the day.

Such is the problem with which we, who strive to assist in establishing aviation with as good a reputation for reliability as other forms of transport, are faced. Many potential air travellers and trainees will be turned away to-day with thoughts of "another wasted day," and will no doubt ponder on the advisability or otherwise of trying to make progress or a living in the air when London smoke and a water-laden atmosphere conspire so frequently as they do to cause such waste of time and money. Let us consider for a moment how these unpleasant conditions come about. Many factors can of course be responsible for fog formation, but the first essential for the most potent form is the existence of suitable nuclei in the atmosphere. Household and factory chimneys provide the most effective form of nuclei, prolific in sulphur dioxide, and usually rendered highly hygroscopic by sunlight, they have a marked capacity for attracting water even in unsaturated atmosphere, and thus constitute the greatest menace with which we have to contend in the air, and one which has ended the lives of many of the bravest and best fellows that ever lived.

Of course, we can do much with expensive and complicated ground organisations. Radio can now not only bring the pilot to his home aerodrome, but can also get him back safely on the ground without any view outside his cabin windows. But can any, other than the largest concerns, face the expense involved, and what will be the state of things in the air when there are ten machines approaching every aerodrome for each one machine to-day? And even if the increasing traffic can be coped with, which I doubt, I cannot help visualising those little glass valves and other frail parts of the radio equipment upon which so many lives depend, and feeling that this vast problem is being tackled in the initial stages from the wrong end.

Those who have travelled by air over such countries as Germany and Switzerland will know what I mean when I say that until we take this smoke business seriously in this country, not only will our

progress in the air be seriously retarded, but also that our very lives on the ground must be affected.

On the other hand, take a flight some day towards the north of England. Notice how carefully the pilot studies the weather reports. Observe how anxiously he watches such towns as Birmingham and Manchester, and how rarely these towns can be seen from the air. A really good example of the atmosphere we are content to live in may be obtained by flying a fast aeroplane fairly low over any one of our large towns. When you land, walk round and examine the leading parts of the machine. You will find that the leading edges of the main planes and the tailplane, the windscreen, and the blades of the propeller are all covered with a layer of grime, sooty and greasy.

This is no exaggeration, as those who know such conditions will agree. Take an aeroplane trip on the next fine day. You will find it immensely difficult to believe afterwards that what you see on the ground can have any connection with the dismal picture of drifting smoke and haze and belching chimneys, and the countless houses bathed in an obviously polluted atmosphere that passed beneath you a short time before.

I should like to tell of the experience of one of our leading pilots a few years ago, which is not without its humorous aspect. This fellow was bringing his machine, full of passengers, towards the home aerodrome, when he ran suddenly into a bank of fog. He expected to be diverted by radio, and told to land elsewhere, but to his astonishment and dismay, he was told to come on and that an attempt would be made to direct him on to the ground by radio telephony.

He came on, his only guide the comforting voice of the control officer in his earphones, and hoped for the best.

Suddenly the voice ceased, the radio had failed. He stuck to his course and prayed that he might be sufficiently near to see the red glow of the huge neon beacon in due course.

An age passed, he had lost count of time, when he suddenly saw a red blush in the fog below. He circled slowly, watching anxiously, the glow seemed to be unduly elongated. He went a little lower and discovered that it was a two word sign—"Bon Marche." He knew his London, and he kept his head, and landed his passengers safely, but can you imagine his feelings and what he might have said if asked his opinion of London smoke?

I wish I could feel that these words of mine would do something towards strengthening the efforts of the N.S.A.S., by opening the eyes of the many people who, by influencing rational town planning and establishing logical and modern power and heating systems, could do so much to improve the health and outlook of the nation, and what is perhaps more important to me, really do something to put aviation more firmly on the map as a reliable and everyday form of transport.

THE DOMESTIC SMOKE PROBLEM

WITH SPECIAL REFERENCE TO THE NEW HOUSING ESTATES

By MARION FITZGERALD, Assoc. Roy. San. Inst.

BY this time it may be assumed that all unbiased people have ceased to dispute about the relative amount of smoke contributed by factory and house chimneys respectively, and are agreed that a campaign must be waged simultaneously against both sources of air pollution.

The domestic smoke problem is prominent at present on account of house building carried out since the War and still going on, and there is, unfortunately, evidence to prove that the large new estates which have been developed on the outskirts of most towns have spoilt one of the chief suburban amenities—relatively clean air. A resident in what was once a Cheshire village now absorbed into Manchester's great garden suburb, Wythenshawe, has supplied the writer with specimens of muslin hung for short periods in the attic windows of her house in order to test the cleanliness or otherwise of the air. They present a very dingy appearance, and the sender recalls with regret that twenty years ago her window curtains only needed washing once in about four months. More evidence as to the effects of smoke from house chimneys comes from further south. In a recent communication to the National Smoke Abatement Society from Welwyn Garden City, Ltd., a public utility society which has built a very large number of houses, the following statement occurs: "Even on this estate exterior paint-work is spoilt by soot and smoke shortly after the work has been done." Everybody knows, of course, that at Welwyn Garden City and at Wythenshawe, industrial smoke is supposed to be non-existent.

Although to some extent dust from the many new roads which have been made to serve these new estates and the great increase of road traffic have added to the amount of dirt in the air there is no question that the enormous number of new chimneys are responsible for the larger share. Before considering what can be done to repair the disaster, and to prevent its recurrence in the future, it would be well to inquire what steps, if any, local authorities and other house-builders have taken to reduce smoke from domestic chimneys. What kind of heating and cooking appliances have they installed?

Smoke prevention and labour-saving ideals were urged at the outset of post-War house-building; many committees sat and deliberated and made recommendations. The Departmental Committee on Smoke Abatement, believing the house chimney to be of such importance at the time, issued an interim report in 1921 urging that the Minister of Health should insist on smokeless methods of heating and cooking so far as possible in all new houses that were eligible for subsidy.

Considering that the time had come to make an inquiry as to what was actually being done as regards heating and cooking

appliances in the new municipal houses, the N.S.A.S. recently sent out a questionnaire to all the larger local authorities, asking what their own practice was, and that of private builders in their area. Copies of the questionnaire were also sent to the voluntary housing societies. It is not proposed to deal at length with the replies here ; all of them are not yet to hand, and it is the intention of the society to issue a full summary and report later. We can, however, as it were, skim the cream off the answers that have been received.

To begin with, it is evident that in very few places are municipal tenants dependent on coal fires alone for cooking. There is almost invariably a smokeless alternative, even—and this is rather surprising—in some of the mining areas where the miners get free coal.

Practically every house has one coal fire—even those which are mis-named “all electric” or “all gas.” There are just a very few exceptions to this rule, but so few as to be negligible. They were tried and proved unpopular.

There is a great variation in the method of supplying the alternative smokeless appliances. Some local authorities instal gas cookers free of charge ; others put them in the houses as a routine practice but charge for hire ; others again fix gas points in appropriate places and leave the tenant to make his own arrangements with the gas undertaking. Similar arrangements are made with regard to electricity : either the cooker is supplied on simple hire or on hire-purchase, or the power points only are fixed and the tenant can make what arrangements he pleases. Gas and electric fires if installed in bedrooms in the place of open grates are fixed free ; when gas or electric points are fixed in addition to fire grates there is usually a charge for fixing fires if the tenant desires to have them. Where electric grillers or cookers are supplied in the new houses and flats which are being built for the rehousing of people from slum clearance areas it is found to be a convenient practice to collect the fixed charge and hire of apparatus weekly with the rent, the tenant paying at the rate of a halfpenny or three farthings a unit through a slot meter for the current he uses.

Electricity, when the fixed charge does not exceed 6*d.* or 7*d.* a week, with current at a $\frac{1}{2}$ *d.* a unit, seems to be found practicable for all uses except long period room heating. The introduction of the two-part tariff for gas—the tenant paying a fixed charge, in the case of small houses 7*s.* 6*d.* or 10*s.* a quarter, and getting all the gas he uses at a low cost per therm—is going to make a great difference in costs especially where the water-heating is done by gas. Several local authorities replying to the questionnaire report the introduction of the two-part tariff for gas in their area.

Beyond being supplied at a low cost there are other essentials in connection with the successful uses of these two smokeless fuels. One is instruction in their proper use ; another is the collection of charges in a manner suitable for weekly wage-earners to whom quarterly bills are a bugbear. In the case of the poorer people the fixed charge and hire charge, if any, should be collected weekly, and the prepayment meter system be available for electricity as it has long been for gas.

For the most part the answers to the questionnaire tend to prove

that women in these new houses do actually prefer to cook by means other than the coal fire though the evidence is a little conflicting. A great deal will naturally depend on local prices—one would not expect anything but raw coal to be used in a district where gas and electricity are both very dear—and custom and prejudice count a good deal. From a Housing Trust in the north of England comes the blunt assertion, “Tenants hate anything except a blazing smoke-producing fire.” In that district there is a great deal of unemployment, and possibly underfed people are craving for warmth.

Now that the local authorities are building almost entirely to rehouse people from the slum clearance areas who need rents on the low side, it is a little surprising to note how much use is being made of gas and electricity. It is definitely encouraging from the smoke abatement point of view, and in view of the fact that these houses, in particular the great blocks of flats, are destined to last a very long time, and also that great developments are taking place as regards the supply of gas and electricity, it is a wise step. It seems also to be the practice in the new “luxury flats” now going up all over London to put only one open fire, with gas or electricity, or a combination of the two, for all other purposes. In a specimen flat recently seen by the writer rented at £550 a year that was the arrangement, the landlords supplying the domestic hot water and central heating.

It would appear then that an increasing use is being made of the two smokeless fuels, gas and electricity, by rich and poor alike. This is all to the good, but we still have a domestic smoke problem. True, most of the new houses have one coal fire only, but there are three millions of those new houses. Must the one open fire then be abolished? One hopes not. It would be a very unpopular proposal and one would not like to make it in a summer like the present one when a small comforting fire is most acceptable on chilly wet evenings.

There is now happily real ground for hope that we need not forego our cherished open fire. To preserve it while not polluting the air with soot we need :—

- (a) Supplies of solid smokeless fuels—and these of different kinds in order that people may exercise a choice—in sufficient quantity and at reasonable prices ;
- (b) Grates constructed so that these fuels may ignite readily, and the fires require not too much attention ; and
- (c) Willingness on the part of the population to use smokeless fuel in preference to coal.

Now while it would be idle to pretend that all these conditions have been fulfilled one can assert definitely that they are on their way towards fulfilment. True there is not yet a sufficient supply for all the households in the British Isles to burn nothing but smokeless fuel, but much progress has been made in recent years, and there are more of these fuels to choose from than is generally recognised. To begin with, it is possible that enough use is not made of the natural Welsh smokeless coal which can be burnt in open grates when graded to appropriate sizes. There are now several kinds of low-temperature coke, and there is also good quality

gas coke which is growing in popularity on account of its relative cheapness. The manufacturers of grates have produced many types in which coke will burn freely. In addition to allowing a good supply of air to the fuel bed these grates are usually fitted with some form of gas ignition which is a very great asset. To be able to start the fire with a gas poker or with gas jets placed below the fuel bed without having to trouble about paper and wood, and to be able to enliven the fire by the same means when it "burns dead," will prevent that discouragement which in the past has sometimes attended well-meant experiments with those fuels which are more difficult to ignite than raw coal. A fair number of replies to the N.S.A.S. questionnaire reported experiments with gas-ignited coke fires by local authorities in their new houses.

As regards the willingness of people to use smokeless fuels, personal investigations have revealed a surprising predilection amongst working-class people. Tenants in some new working-class flats in London were found by two inquirers from Manchester to be making a great deal of use of a form of "coalite," which, they explained, they could buy conveniently in 28-lb. bags at a shilling each. Since then the writer has seen notices in innumerable greengrocers' shops in London announcing that this fuel is on sale. As the price seemed high, inquiries were made of one shopkeeper in a very congested part of Southwark, and he said he had a very great demand for this smokeless fuel; the people found it made less mess, and, he added, "You wouldn't have thought they would have bothered in a district like this." As raw coal can be bought easily in London from itinerant vendors in small quantities at a much lower cost a large demand for smokeless fuel, even though it costs more, is a very encouraging sign.

The one immediate reform that is needed now, so far as the new housing estates are concerned, is that it should be made compulsory to fix grates that are capable of burning coke as well as coal.

From what has been learnt of the present-day customs of local authorities and of private builders, as well as a growing preference on the part of the people for cleaner methods, one may conclude that the domestic smoke problem, though real, is capable of solution in a not too distant future.

EFFICIENT INDUSTRIAL STEAM RAISING

By G. W. ANDREW

Technical Officer, Federation of British Industries

IT is generally agreed that the promotion of efficiency in industrial steam raising is one of the most important aspects of national fuel practice but, unfortunately, there is comparatively little conclusive information on the subject.

The statistical tables published by the Mines Department show the allocation of coal consumed in Great Britain during six recent years, from 1929 to 1934, to be as follows :—

Consumer	1929	1930	1931	1932	1933	1934
Quantity (Million Tons)						
1. Gas Works (excluding the coal equivalent of gas coke exported)	16·75	17·00	16·69	16·37	16·16	16·66
2. Electricity Generating Stations belonging to authorised undertakings and to railway and tramway authorities ...	9·84	9·68	9·61	9·81	10·33	11·17
3. Railway Companies (for locomotive use)	13·41	12·87	12·27	11·70	11·67	12·17
4. Vessels engaged in the Coastwise Trade (bunkers)	1·37	1·28	1·19	1·19	1·21	1·26
5. Iron Works (used in Blast Furnaces)	14·51	11·69	7·11	6·56	7·37	10·40
6. Other Iron Works and Steel Works	8·92	7·10	5·50	5·37	5·70	6·81
7. Collieries (engine fuel) ...	13·69	13·51	12·61	12·04	11·59	11·68
8. General Manufactures and all other purposes (including Domestic use)	95·01	93·45	90·70	86·46	84·34	91·33
Total	173·50	166·58	155·68	149·50	148·37	161·48

The subject of efficient steam raising, from whatever standpoint it may be approached, has the same ultimate objective, namely that of producing, in any given plant, the quantities of steam demanded for external use, as and when required, at the minimum cost of which the particular circumstances admit.

Obviously this total cost must include the whole of the contributory items such as fuel, labour, water and water treatment, stores, plant maintenance and repairs and capital charges, but the treatment of the subject in this article is intentionally confined to matters affecting the fuel cost in steam raising for two principal reasons. In the first place the cost of fuel is almost invariably the

dominant item in the total cost and often amounts to 70 per cent. or more of the whole ; moreover, whilst many of the other component items are fixed within comparatively narrow limits by the type of plant provided and the working conditions, the cost of fuel is the item which may be affected in a considerable degree by the proper selection of an economical fuel and the care with which the plant is equipped, maintained and operated.

The problem of obtaining the maximum efficiency in this sense may be approached from one or other of two separate standpoints. It may be regarded as mainly a technical question involving the selection of the most advantageous fuel available and the use of such fuel with maximum thermal efficiency or, on the other hand, it may be considered in terms of the fuel cost per unit quantity of steam raised available for external purposes. There is, however, no single criterion by which the commercial efficiency of steam-raising can be satisfactorily stated for comparative purposes, in a general and unqualified way, as between plants operating under different conditions.

THE SELECTION OF FUEL

The results of analyses are not of very considerable value in enabling the quality of fuel to be selected satisfactorily on this basis alone and without reference to other properties which may exercise an important, and even a decisive, influence. For example, such factors as the character (as distinct from the percentage) of the volatile matter, the combustibility of free-burning properties of the fuel and the degree of coking or clinkering in the combustion process are each of considerable importance from the practical standpoint.

This limitation does not mean that the proper analysis of fuel is without value ; on the contrary, it is of importance for many reasons, including the following :—

- (a) Among fuels which are otherwise suitable those having a maximum calorific value per unit of cost are obviously to be preferred ;
- (b) The determination of calorific value prevents a free-burning fuel of low calorific value from being regarded as a good fuel merely because it enables a satisfactory rate of steam production to be maintained ;
- (c) When a particular fuel has been adopted for regular use, analysis enables changes in quality in actual deliveries to be followed quantitatively ;
- (d) Information in regard to the quality of fuel, as delivered in actual practice over a period, is of great assistance in connection with the placing of new orders.

For reasons which have been indicated already it is usual, at the present time, to buy coal on a specification which indicates the source, *i.e.* the colliery and the seam, and also the size and method of preparation, but the question of suitability is almost invariably decided after, and as a result of practical trial under the conditions of commercial use.

Where the analysis of fuel is made, either for the purpose of

special investigation, or, as a matter of routine test, it is important to ensure that a truly representative sample is taken. Methods of analysis have been carefully standardised and the probable errors reduced to relatively small proportions, but there still remains the possibility of serious error as a result of improper or careless sampling. Sampling errors are likely to be more serious in the case of fuels of mixed sizes than with those which have been prepared by grading but, in all cases, certain procedure is necessary, and being within the capacity of anyone of good intelligence, should be carefully followed.

THE MAINTENANCE OF THERMAL EFFICIENCY

The thermally efficient working of boiler plant may be considered broadly as consisting :—

- (1) In utilising the heat of the fuel as completely as possible in the boiler furnace, and delivering it to the heating surfaces in the form best suited for heat transmission ;
- (2) In securing the best possible transmission of this heat through the plates or tubes of the boiler for the generation of steam ;
- (3) In avoiding, as far as possible, losses of heat from the boiler plant ; and
- (4) In using steam as economically as possible for the requirements of the boiler plant itself, in order to leave the maximum proportion available for external purposes.

1. *How may the heat obtainable from the fuel be utilised as completely and effectively as possible ?*

Complete combustion of coal is secured by :—

- (a) Avoiding wastage of coal or cinders in clinker and ashes ;
- (b) Avoiding the production of smoke, or incompletely burnt gases ; whilst the most effective means of conveying this heat to the boiler surface results from—
- (c) Burning the coal in the furnace with the minimum excess of air ; and
- (d) Thereafter avoiding inleakage of air to the flues or setting.

2. *How may the best possible transmission of heat be obtained in the boiler ?*

The conditions which enable the most effective heat transmission through the plates or tubes to be obtained are :—

- (e) That no by-passing shall take place in the flues or through the baffles ; and
- (f) That sufficient clean heat-transmitting surface shall be provided for the required evaporation.

3. *How may unnecessary losses of heat from the boiler plant be avoided ?*

Under this heading, the losses of heat by conduction, convection and radiation from the boiler and setting, or resulting from hot water or steam discharged or lost from the plant, may be considered. These losses comprise :—

- (g) Loss in heat in blow-down water ;
- (h) Loss of heat due to priming ;

- (j) Loss of steam from boiler fittings, drains, etc. ;
- (k) Dissipation of heat by radiation, etc., from boiler and steam pipes and conduction of heat through the setting.

4. *How may the proportion of steam required in the boiler plant itself be reduced to a minimum ?*

The purposes to which steam is usually applied in the boiler plant are :—

- (l) Operation of feed pumps, stoker gear and fans ;
- (m) Jets giving forced draught under the grates.

It is frequently possible to recover the greater part of the heat of the steam required for purposes noted under head (l).

It is impossible within the limits of the present article to deal, in detail, with the conditions essential to the maintenance of efficiency, for which reference may be made to the monograph on the subject issued by the Federation of British Industries, but the following summary of recommendations may be quoted.

SUMMARY OF RECOMMENDATIONS

Furnace Conditions

1. Avoid unnecessary wastage of cinders in the ashes by cleaning the fires carefully and by providing suitable firebars.
2. Avoid the production of unnecessary smoke or incompletely burnt gases by regular and frequent firing of coal in small quantities, and by keeping a proper depth of fire. Open the air checks in the furnace doors only after firing, at other times keeping the checks closed.
3. Regulate the draught by the damper to burn the coal with a minimum excess of air.
Try to obtain 12 per cent. CO_2 in the furnace gases, and, if necessary, reduce the grate area to secure this result.
4. Keep the grate covered, the fires level and free from holes. Use the rake when necessary.
5. Carefully examine the setting and stop all inleakages of air.

Boiler Conditions

6. Keep the heating surfaces free from soot and flue dust.
7. Keep the internal surfaces free from scale.
8. Do not force the boilers unnecessarily.
9. Examine flues and baffles carefully. Repair where necessary to avoid by-passing.

Heat Losses from Plant

10. Efficiently lag the boilers and steam pipes (including flanges).
11. Do not blow down the boilers unnecessarily.
12. Keep the boilers filled to the working level by a continuous and steady feed.
13. Avoid leakages of steam from boiler fittings, drains, etc.

Use of Steam

14. If steam is used in pumps or auxiliaries, use the exhaust for preheating the feed water.

15. If steam jet blowers are used, keep the jets in good condition by renewal as necessary and regulate the pressure on the jets to the minimum necessary for the load.

Efficiency

16. If economisers are provided record the temperatures of water entering and leaving.

17. Make periodical measurements of CO₂ in, and temperature of, flue gases, leaving the boiler under average conditions, to estimate the approximate boiler efficiency.

FUEL COST PER 1,000 LB. STEAM OUTPUT

The fuel cost per 1,000 lb. of steam produced in the regular operation of any plant should be ascertained and recorded systematically during consecutive weekly, monthly or quarterly periods. The expression "regular operation" is not intended to include the results obtained in controlled and supervised tests carried out during relatively short periods (although these may be of great value for check purposes) but the ordinary results obtained in the day-to-day working of the plant and including the normal losses which arise from the lighting and banking of the boiler fires.

It is interesting to note, arising from data which have been interchanged recently in respect of a very large number of steam-raising plants in the industrial areas and within reasonable distance of the coalfields, that with carefully operated plants the fuel cost per 1,000 lb. of steam output often falls within the limits of 11*d.* to 13*d.* with, say, 12*d.* as an average. There are, however, some notable cases which fall outside these limits in each direction. A number of reliable returns show fuel costs below 10*d.* and several even below 8*d.* per 1,000 lb. steam output, but it should be explained that such exceptional cases refer almost invariably to plants which are favourably situated in respect of fuel supplies and which have made special provision for using the cheaper classes of fuel with good economic advantage.

SMOKE ABATEMENT

The technical aspects of smoke abatement are too complex to be dealt with satisfactorily in any summarised way, and are admirably set out in a pamphlet prepared by the Manchester and District Regional Smoke Abatement Committee.

THE PROBLEM IN OTHER COUNTRIES

COMMUNICATIONS FROM CORRESPONDENTS ABROAD

BELGIUM

LEGISLATION, which was revised in 1923, has existed for some time in Belgium, for controlling the installation and management of industrial plant capable of causing danger to life or interfering with the reasonable comfort of persons employed on the premises or living in the neighbourhood. Under such legislation the approval of plans and the inspection of premises used for such dangerous or unhealthy trades rests with the Ministry of Labour or the Ministry of the Interior and Health. Administrative or judicial penalties for infringements of the law were seldom applied prior to 1930, except as a result of civil proceedings where damage had been caused to vegetation in the neighbourhood of factories, and in the case of accidents happening within industrial premises, when the supervision exercised by the Factory Inspectors was particularly severe.

The fight against air pollution has been pursued much more actively since December, 1930, both in scientific research and in matters of administration, as a result of the great feeling aroused in the country, and indeed elsewhere in the civilised world, by the catastrophe which followed four days of fog in the Meuse Valley above Liège, when not less than seventy persons met their death and many thousands of others were the victims of sickness.

In the scientific field a committee of experts composed of five professors of the University of Liège and one professor of the Military College, was appointed shortly afterwards by the Chief Law Officer of the Crown to examine the causes of the catastrophe. After giving careful consideration to the medical findings and the reports of meteorological conditions and of the chemical composition of the atmosphere in the affected district during the period of the fog on the one hand, and on the other hand to the calculated quantities of the gases emitted as estimated by the chemists having regard to the total consumption of fuel and other matter burnt during the same period, this expert committee was able to prove conclusively that the serious nature of the accident was entirely due to the overloading of the atmosphere with sulphur-charged particles and doubtless also with sulphuric acid. Thus the attention of the responsible authorities and of public opinion was drawn to the dangers of atmospheric pollution in particular industrial districts.

On the administrative side, a commission presided over by the Viscomte Berryer and composed not only of University professors but also of representatives of industry and of trade unions, proposed that additions should be made to the statutory law then

existing. It was pointed out that though this may have been adequate for the control of atmospheric pollution within industrial premises it did not sufficiently take into account the interests of the general public living outside the factories.

A monograph was published in 1933 with the title "Problems of Atmospheric Pollution." * The problem was there dealt with as a whole in its technical, meteorological, medical and social aspects, and reference was made to the general policy adopted in other countries and especially in England, where the work of the National Smoke Abatement Society and the annual reports of the Committee for the Investigation of Atmospheric Pollution had already rendered such important service. It was suggested that there should be set up research centres specialising in the subject, and particularly preparing charts indicating the extent of atmospheric pollution at different periods of the year, having regard to meteorological conditions in the districts where the danger seemed greatest.

The suggestions, both administrative and scientific, were largely adopted. The Belgian Government took steps to put into effect the suggestions of the Berryer commission. On the initiative of those engaged in industry a further attempt was made to remedy the causes of atmospheric pollution by processes designed to recover the products of combustion previously discharged into the atmosphere.

Various University laboratories, particularly those in Liège and Louvain, turned to a general attack on the problems relating to pollution, especially the analysis of dusts, the production and poisonous effects of arsenic hydride (arsine), silicosis, research into the sulphur compounds contained in smoke and fumes, the revision of methods for the preparation of charts of dust and grit pollution, the perfecting of general methods of atmospheric analysis, air conditioning, etc.

The Ministry of Labour at Brussels has modernised the installation of its laboratories for the study of methods of protecting the worker, and has brought together a most important collection of books and pamphlets dealing with air pollution. The Ministry also makes use of travelling laboratories which can be sent out as required for the analysis of the atmosphere in various parts of the country.

G. BATTA, Dr.Sc., J. FIRKET, M.D. and
ED. LECLERC, Ing.A.I.Lg.

University of Liège, Belgium.

CANADA

Although a byelaw prohibiting the contamination of the atmosphere by dense smoke has been in force in Toronto, Canada, for a number of years, the condition of the city's atmosphere leaves much to be desired. Due to the interest of Dr. J. G. FitzGerald, Director of the School of Hygiene, University of Toronto, a pro-

* "Les problèmes de pollution de l'Atmosphere," par G. Batta, J. Firket, et E. Leclerc. Edit. Thone, Liège, 1933.

gramme of research in the Department of Physiological Hygiene was instituted in 1932. The programme had two objects in view : first, the collection of data indicating the degree of pollution actually present in Toronto air in the hope of using this information as a means of bringing about an abatement of the conditions, and secondly, an attempt was made to demonstrate possible effects of a contaminated atmosphere on health.

To make the Toronto observations of comparative value the technique developed by the Committee on Atmospheric Pollution in the British Isles was adopted. Four gauges of the type recommended by the Committee were placed at strategic points in and about the city. In addition, an Owens automatic filter has been in continuous operation at the School of Hygiene during the past three years.

The locations of the four gauges were chosen to indicate a variety of conditions. One was placed in the centre of the business district, one at the University surrounded largely by residential property but also proximal to a number of large public buildings, one in an industrial section with railway yards closely adjacent, and the fourth, located some six miles outside of the city, served as a control.

The results of the observations, a portion of which has been published,* will be only briefly summarized. The condition of Toronto's atmosphere is comparable to badly polluted areas in the British Isles ; for example, the average total deposit of the three gauges located within the city amounted to over 40 tons per square mile per month, the gauge outside the city showed an average of only some 11 tons per square mile. The degree of pollution indicated by the gauges placed in the business section and at the University was closely related to the temperature, showing marked increase in the colder months. This was not true of the other two stations, indicating that a large proportion of the pollution resulted from heating plants and was not industrial in origin.

The observations are still being carried out and it is hoped, with the assistance of the Toronto Smoke Control Association, a group which have been carrying on a valuable educational and publicity campaign, to bring about a more effective control of the smoke problem in this city.

It has been amply demonstrated in the British Isles and in the United States that appeals based on the tremendous economic wastage resulting from smoke pollution are remarkably ineffective in bringing about an abatement of the evil. For this reason a more powerful lever is necessary. This would be at hand if it could be conclusively demonstrated that smoke possesses a deleterious effect on health. Unfortunately this problem presents a most difficult approach and although the feeling is more or less general that a smoky atmosphere cannot be conducive to healthful living, definite proof is lacking.

One of the most widely discussed effects of a smoky atmosphere is its power to absorb the sun's energy, particularly the short ultra-violet region of the spectrum. The question is, is this screening

* *Modern Power and Engineering*, January, 1934.

sufficient to be harmful? Although many physiological effects are ascribed to ultra-violet energy, the only measurable one is that exercised by a narrow band in the short ultra-violet which is a prophylactic and therapeutic agent in rickets. It is true, of course, that other spectral regions may in time be demonstrated to have other specific effects, but at present the so-called antirachitic band offers our only means of assay. In a controlled experiment carried out in Toronto,* it was found that smoke in concentration normally occurring in urban atmospheres was sufficient to shield rays to an extent where they ceased to prevent the development of rickets in rats. Further work on the problem is nearing completion, in which it is hoped to correlate entirely the animal experiments with the effect on human beings.

HUGH M. BARRETT,

Research Associate in the Department of
Physiological Hygiene, School of Hygiene,
University of Toronto.

FRANCE

The pollution of the atmosphere of large towns in France results, in great measure, from the emission by chimneys of smoke or fumes, *i.e.* of the products of incomplete combustion of the fuel employed, both in industrial and in domestic fireplaces. But if industrial furnaces might, at first sight, by reason of their more imposing size, seem to be the principal agents in the production of smoke and fumes, it is easy to realise, by considering the matter a little more closely, that in a city like Paris, for instance, the quantity of fuel burnt in domestic grates would be represented by the coefficient 90, while that burnt in industrial furnaces would only be represented by 10.

It is, therefore, domestic fireplaces, where the fuel used is almost exclusively raw coal, which in large towns, such as Paris, are the main source of smoke and fumes.

Smoke produced by the burning of raw coal consists of small carbonaceous particles, which are carried by air currents and come gradually to settle on the buildings and on all objects within a greater or less distance from the point at which they are emitted.

We have said that these particles are carbonaceous, but this does not mean that they are made of pure carbon; in fact, they are composed of hydrocarbons, very rich in carbon and, consequently, very deficient in hydrogen, which have come into existence during the combustion of the fuel used in the fireplaces and have escaped the process of oxidation generally known as combustion.

These particles are in addition impregnated in varying degrees with sulphur dioxide, the gas resulting from the burning of the sulphur contained in the fuel used. This sulphur dioxide is given off with other gaseous products of combustion and on coming into contact with the carbonaceous particles is adsorbed by them;

* "The Antirachitic Effect of Ultra-violet Radiation transmitted by a Smoky Atmosphere." *Journal of Industrial Hygiene*, September, 1935, 17, 199-216.

little by little in contact with the atmosphere and the moisture it contains, this adsorbed sulphur dioxide takes in hydrogen and oxygen and is transformed into sulphuric acid, with the result that the deposits derived from these carbonaceous particles become veritable sponges containing sulphuric acid in varying degrees of concentration, in a proportion, for example, of several units of acid to every hundred units of the deposit.

When these sponges form on the surface of stones containing lime, they coat the stones with a black film which has harmful effects on underlying stone not only because of its unattractive colour but because the sulphuric acid present, loosened by damp and rain, attacks the lime in the stonework, changing it to calcium sulphate. This calcium sulphate solution in the rain water penetrates the limestone in contact with which it was produced, and after penetrating below the surface of the stone undergoes a process of crystallisation. Such crystallisation being accompanied by an increase in the volume of the sulphate produces in stones covered with soot an effect analogous to that which is suffered by porous stone affected by frost, and results in a visible breaking up of the stone and causing it gradually to powder away.

To this cause we owe the destruction of considerable portions of many priceless monuments of architecture. The fact is that the coating resulting from soot has been confused with another kind of coating which takes place far from industrial centres and inhabited areas on stones affected by weathering. The latter coating is generally known as “calcin” * on account of the apparent surface “calcination” which it gives to stonework.

The true “skin” which has its origin in such weather conditions is merely a deposit of calcium carbonate very finely granulated, which forms when rain water charged with carbon dioxide dissolves some of the lime in the stone with which it comes in contact, thus giving a solution of calcium bicarbonate, from which on evaporation is precipitated the deposit of carbonate resulting from the breaking up of the bicarbonate. In brief, stone, consisting as it does of calcium carbonate more or less roughly granulated, in taking on this colouring of “skin,” is superficially coated with a deposit of calcium carbonate much more finely granulated and in consequence is better protected than it was previously to the formation of the skin.

This explains why architects, who were familiar with this process of natural “calcination,” have generally advised that it should not be interfered with, but latterly in our towns the pseudo-skin resulting from a deposit of soot has been confused with the real skin formed of calcium carbonate. In other words, people have confused a protective coating with one which instead of protecting attacks the underlying stonework.

This explains also why the task of cleaning the surface of stonework in our towns affected by this pseudo-skin has been far too long neglected.

* British investigators use the term “skin” for this coating. Often this “skin” has a semi-glossy surface which is similar in appearance to various commodities made of clay (tiles, etc.), which, during their manufacture, have been submitted to elevated temperatures.—ED.

The only effective remedy as a precaution against these deleterious effects is to make use of fuels already partially distilled, that is of semi-cokes in the various forms in which they are now being produced.

The use of oil fuel for domestic and industrial heating purposes is not entirely effective against the damage to which I have referred above, owing to the fact that such oil fuel contains more than a negligible proportion of sulphur (averaging one to two per cent.), but when the oil fuel burns it does not usually produce soot and so the sulphur dioxide resulting from the combustion of the sulphur escapes freely and dissolves in rain water which transforms it into sulphuric acid. The proportion of sulphuric acid in rain water so affected is, however, too slight to produce any damaging effects on the materials of buildings and monuments on which such water ultimately falls in the form of rain.

ANDRE KLING, D. es Sc.,
Director of the Municipal Chemical Laboratory,
City of Paris.

GERMANY

A review of the efforts towards smoke abatement which began in England and Germany about a generation ago, having regard to the results so far achieved and to the great number of chimneys still smoking excessively, must recognise not only the very slow progress that was inevitable in face of the great initial difficulties but also the indisputable benefits in fuel technology that arose out of the recognition and inspiration of the smoke abatement movement. At the beginning, smoke abatement faced a void; experience and technical aid were wanting, and the only possibility of exerting influence lay in the education of stokers in expert handling of fuel and in weeding out erroneous firing methods step by step as they came to be recognised.

All institutions that have taken up the abolition of the curse of smoke have had to tread this wearisome way. Results have not been wanting, and to-day the technology of firing has available a deep insight into the processes of combustion, and above all it is known that the combustion of fuel is fundamentally a question of aero-dynamics, but in many cases this knowledge emphasises the difficulties that face effective smoke abatement.

Now that the armour of this theoretical knowledge has been abundantly gained smoke abatement must energetically attack the practical solution of the task. The real beginning has only come with the modern water-tube boiler which involves no difficulty in the avoidance of smoke. Technical remedies are still undeveloped in the case of the older and smaller plants, especially Cornish boilers, that is to say, just the types most prevalent and of greatest concern to public health. Owing to varying working conditions the Cornish boiler needs individual treatment and is thus the more troublesome, whilst with its restricted space it entails greater difficulties in firing. This explains, on the one

hand, the frequent failure of the innumerable smoke consumers that do not take into consideration the individual case, and also on the other hand the attempt to get rid of smoke by installing mechanical stokers ; but this is to circumvent rather than to solve the problem ; doubtless, too, there is an inequitable feature in the fact that smoke avoidance is said to be much more costly in the case of the small boiler than in the large water-tube boilers, for which the apparatus costs but little.

In the manual firing of a small boiler the stoker has much more influence on the smoke production than with automatic stokers, which for the most part are on a high level of mechanical development. Important as it may, therefore, still be to educate the man in front of the fire to the expert use of coal, it remains desirable in regard to smoke abatement that we should make ourselves as independent as possible of his skill and conscientiousness. Then considerations have led the Society in Hamburg to apply to the Cornish boiler the sound experience obtained with water-tube boilers. The top draught necessary for smoke consumption is now applied even in the case of small installations with accurate regulation of direction and quantity ; experience shows that by these means results can be got even in those cases that formerly had to be counted as insoluble.

The removal of dust from discharged gases is nowadays entirely successful, be it by wet or dry process. Unfortunately all this progress in the abatement of smoke, soot and dust is only of benefit in the industrial installation ; in domestic firing the solution remains first and last a question of fuel.

Dipl. Eng. W. BURGEDORFF,
Chief Engineer, Society for Furnace Management
and Smoke Abatement, Hamburg.

UNITED STATES OF AMERICA

Smoke abatement activity in the United States is progressing with renewed vigour after something of a lull during the depression years.

As industrial activity declined in the early 1930's, some cities set aside their anti-smoke ordinances temporarily. Others reduced enforcement staffs, leaving little more than a skeleton of an organisation. Still others, profiting by past experience in the difficulty of regaining lost ground, continued to fight the nuisance as usual, with due regard to such economies in enforcement procedure as could be made without undue lessening of efficiency.

Returning industrial activity again has brought the subject to the fore. It is being discussed in the daily press, in technical journals, at meetings of societies and of civic organisations. While many cities still are lagging, some have returned to their former standards of regulations, others are considering the framing of more stringent laws, and a few have passed such laws and have them in operation.

During the past several years, some cities have taken advantage of the system of Government-supported work relief to have groups of qualified engineers, chemists, physicists and physicians gather

pertinent information upon which further work might be predicated.

A few examples will illustrate the types of such activities.

In a number of cities—among which were Chicago, St. Louis and Pittsburgh—inspections were made of practically all fuel-burning plants to determine whether or not they were of types, so installed and so operated, as to meet the requirements of fair anti-smoke regulation ; if not, in each case the advisable corrections that should be made were suggested—new boiler, repairs to boiler, more chimney, different fuel, modified method of firing, etc. The value to an enforcement officer of a record of such scope is obvious. It is equally obvious that, with a normal force of inspectors, there would not be time to obtain information on such a scale.

In the city of St. Louis, the medical association has assumed a rightful position in the lead of the associated groups that are making a comprehensive study of the problem, with a view of evolving most effective regulatory measures consistent with practicability.

New York City has received a Federal grant for the study of atmospheric pollution in that metropolis. A large force is collecting data on fuel-burning plants and plant operations, sootfall, suspended solids, etc., and will also endeavour to determine the degree of responsibility of nearby communities for air pollution that is found in New York. It is to be hoped that any resultant efforts at control may be co-operative.

Washington, the nation's capital, has this year put into effect a completely revised anti-smoke law. This new law gives rather broad powers to the enforcement department, and should be productive of good results if a proper budget is provided.

The special work that has been done during this period and is being continued in Pittsburgh has had to do more with medical, chemical and physical investigations than with engineering. There may be mentioned the critical study of 2,500 human autopsies to determine particularly the amount and indicated effects of carbon particles in the lung ; tar in soot, its composition and an introduction into methods of determining its effects on experimental animals ; the effects on experimental animals of mixtures of air and gases from different fuels ; attempts at development of simpler sampling and measuring devices for air pollution ; etc.

Other cases might be cited, but the types of activity mentioned may be considered as indicating that the subject of smoke abatement is very much alive in the United States. There will be in the near future new ordinances in many cities, and the remodelling of old ones in other cities ; it is likely that, on the average, these may be expected to be more stringent than the type of regulation in effect during the past ten or twenty years.

In short, smoke abatement activity in the United States, retarded during the depression years, is now advancing with a revitalised force.

Dr. H. B. MELLER,
Air Hygiene Foundation of America, Inc.,
Pittsburgh.

CATALOGUE OF EXHIBITS

The Exhibition is divided into three main sections :—

- (1) Smoke and its effects.
- (2) Measurement of smoke and pollution.
- (3) Methods for the abatement of smoke.

SMOKE AND ITS EFFECTS

1. A LANCASHIRE COTTON TOWN.

A photograph originally appearing in *The Times* and copyright by that newspaper.

2. THE POTTERIES.

A photograph originally appearing in *The Times* and copyright by that newspaper.

3. INFRA-RED PHOTOGRAPH OF LONDON AND ENVIRONS.

This remarkable photograph, taken by the journal *Flight*, shows the extent to which the smoke pall impedes even the penetrative infra-red rays. This is indicated by the screening of London and even of Hyde Park and other open spaces compared with the rural areas beyond. A key diagram and detailed particulars are given below the photograph.

4. AERIAL PHOTOGRAPHS BY CAPTAIN ALFRED G. BUCKHAM, F.R.P.S.

Captain Buckham's aerial photographs are noted for both their technical and pictorial qualities, and the prints exhibited are outstanding records of the smoke pollution of our cities as it is seen from the air. They were used by Captain Buckham to illustrate one of the papers in a conference on "Smoke and Aviation," a report of which is obtainable at the bookstand.

5. HALF-CLEANED OIL PAINTING. (By Rosa da Tivoli, 18th century). Lent by Messrs. Frank Partridge and Sons.

The cumulative effect of years of exposure to a city atmosphere is strikingly shown by this painting, one half of which has been cleaned and so gives some idea of the original brightness of the colouring.

6. TRANSPARENCIES OF SMOKE ABATEMENT PHOTOGRAPHS OF GENERAL INTEREST.

7. SPECIMENS OF SOOT-INCRUSTED STONE AND BRICK. Lent by H.M. Office of Works.

The blackening and decay of stone and brick by soot from smoke-laden city atmospheres are strikingly shown by several examples from various public buildings.

8. PHOTOGRAPHS OF STONE- AND BRICK-WORK SHOWING THE EFFECTS OF ATMOSPHERIC POLLUTION. Lent by H.M. Office of Works.

The photographs illustrate various kinds of deterioration caused by different polluting agents in the atmosphere.

9. PHOTOGRAPHS SHOWING THE EFFECT OF ATMOSPHERIC POLLUTION UPON BUILDINGS. Lent by A. R. Warnes, Esq.

The photographs have been selected to show the effect of atmospheric pollution on different kinds of stonework. They include examples of Beer, Portland, Caën, Red Bromsgrove and Ham Hill Stone.

9A. CRYSTAL OF CALCIUM CARBONATE (CALCITE) COVERED WITH CRYSTALS OF CALCIUM SULPHATE. Lent by A. R. Warnes, Esq.

The crystals of calcium sulphate ($\text{CaSO}_4, 2\text{H}_2\text{O}$) were formed by acting upon the calcite (CaCO_3) with a solution of ammonium sulphate. Ammonium sulphate occurs in soot, and the building stones known as limestones are composed chiefly of calcite. The calcium sulphate formed by the action described is destructive to stone.

- 9B. MICROSLIDE OF SMOKE-AFFECTED SANDSTONE. Lent by A. R. Warnes, Esq.

The sandstone was removed from a building in Manchester. It was covered with a hard black coat. Some of the coat was removed by scraping and boiled for an hour in concentrated hydrochloric acid, and the microslide shows the quartz grains after this treatment. Some of them are clean, but others, even after this drastic treatment, are seen to be still covered with a layer of calcium sulphate and soot.

- 9C. NATURAL SIZE PHOTOGRAPH SHOWING PORTIONS OF A PORTLAND STONE PATERA ABOUT 130 YEARS OLD. Lent by A. R. Warnes, Esq.

The photograph shows the thickness of the layer of sooty matter, the thickness of the calcium sulphate "skin" and the depth of the stain. All of these effects are caused by polluted atmospheres.

10. SERMON IN STONES. A PHOTOGRAPH OF KING STREET, MANCHESTER.

The photograph was taken shortly after the completion of a new building, and the contrast between this and similar neighbouring buildings only a few years old demonstrates the rapid blackening of stonework in an industrial city.

11. SECTIONS OF WEATHERED LIMESTONE. Lent by the Building Research Station.

Sections are shown illustrating the characteristic effects of atmospheric pollution as seen in weathered limestone (*e.g.* Portland stone) under the microscope. Limestone taken from rain-sheltered parts of a building usually exhibits a thin surface skin consisting largely or in part of calcium sulphate formed by the action of sulphur acid pollution covered with a deposit of soot and dust. Skin formation is often accompanied by the development of blisters or of cracks parallel to the surface—a process which leads to flaking.

Though chemical analysis almost invariably detects the presence of calcium sulphate in weathered limestone, especially stone which has been exposed in urban atmospheres, it is often difficult to identify it under the microscope. Striking examples are, however, sometimes seen of calcium sulphate (gypsum) crystals formed either in the surface skin or in the pores of the stone.

12. SPECIMENS OF LUNGS SHOWING EFFECT OF ATMOSPHERIC POLLUTION. Lent by Professor S. L. Cummins.

- (a) Lung of child 3 years old, healthy and not yet contaminated by smoke or dust.
- (b) Typical lung of city dweller, showing distribution of carbonaceous dust under the pleura and in some of the tracheo-bronchial glands, with a little dust in the lung tissues.
- (c) Lung of coal trimmer with no chest symptoms. Carbonaceous deposits throughout lung tissue.
- (d) Lung of colliery borer suffering from silicosis. The incombustible impurity of this lung contains 42 per cent. of silica.

13. GRAPHIC CHART SHOWING EFFECTS OF SMOKE-FOG UPON DEATHS FROM RESPIRATORY DISEASES.

Many examples of the increased mortality from respiratory diseases during heavy smoke-fog are given in the literature on the subject. The chart exhibited is one prepared for use at popular health exhibitions, and illustrates in a graphic manner the rise in respiratory deaths in Manchester and Salford during a month in which nine days' fog occurred, compared with the previous and comparatively fogless month.

14. CHART SHOWING EXAMPLES OF FATAL SMOKE-FOGS.

15. ULTRA-VIOLET RAY METER. Lent by Dr. J. R. Ashworth.

This instrument has been designed to enable meteorologists, Medical Officers of Health and others to obtain an approximate daily record of the variations of ultra-violet rays by a rapid and simple method which obviates the tedious operations of instruments of high precision. It consists of three parts:—

- (1) A means of sorting out ultra-violet rays and excluding the visible rays of light.
- (2) A step-by-step method of retarding the passage of the rays metrically.
- (3) A piece of paper sensitive to ultra-violet rays.

The sorting-out of the rays is accomplished by a plate of glass of special make which is opaque to visible rays but is transparent to ultra-violet rays of wave-length between 3,000 and 4,000 Angstrom units with a maximum transmission at 3,600.

The method adopted for measurement is to pass the ultra-violet rays through a step wedge made of layers of wire gauze, so arranged that the steps run progressively in two

rows of six each, making twelve in all. Intensities higher than those which can be measured by twelve steps are read by placing over the wedge additional layers of wire gauze.

15A. LOSS OF ULTRA-VIOLET RADIATION IN MANCHESTER. Lent by the Corporation of Manchester Public Health Department.

The chart shows the relative proportions of ultra-violet radiation, measured by the potassium iodide method, and expressed in terms of milligrams of iodine liberated per day, for Manchester (Town Hall) and Timperley, a village eight miles to the south-west. The loss of radiation is directly attributable to the smoke pall of Manchester and surrounding towns.

16. SPECIMENS SHOWING THE EFFECTS OF ATMOSPHERIC POLLUTION ON VEGETATION. Lent by the Royal Botanic Gardens, Kew.

Apart from the loss of sunlight due to a smoky atmosphere most forms of vegetation suffer directly by the presence of solid impurities and obnoxious gases in the polluted atmospheres of big cities.

Plants reared under such conditions do not attain their full growth and luxuriance, while plants reared in a clean atmosphere are visibly affected when introduced into a polluted one.

Susceptibility to the various impurities differs for different kinds of plants, just as varying climatic conditions affect different species in different ways. Various aspects of the problem are illustrated by the examples shown.

17. INFLUENCE OF GASEOUS POLLUTION IN THE TARNISHING AND "FOGGING" OF NON-FERROUS METALS. Exhibits lent by the Chemical Research Laboratory, Teddington.

Tarnishing is due to traces of hydrogen sulphide in the atmosphere, but the tarnish film (on copper and its alloys) contains both sulphide and oxide.

Thin films of oxide present initially on the surface inhibit tarnishing. These protective oxide films may be produced either by low-temperature heating in air (the thicker films show interference colours, but protection commences at a critical thickness within the invisible range) or by more prolonged exposure to relatively pure air at ordinary temperatures.

Examples include specimens which, following a previous exposure to a relatively unpolluted summer atmosphere, have not tarnished when exposed subsequently to a winter indoor atmosphere of high tarnishing capacity. The phenomenon is also illustrated by means of graphs.

"Fogging" (characteristically exhibited by nickel) is due to the presence of traces of sulphur dioxide, and is dependent on relative humidity rising above a critical value in the neighbourhood of 60 per cent. In the early stages the film consists essentially of sulphuric acid, and it may then be removed simply by wiping with a cloth. Subsequently attack on the metal occurs, with development of basic nickel sulphate. The mechanism consists primarily in adsorption of sulphur dioxide, which, under favourable conditions of humidity, undergoes catalytic oxidation to sulphuric acid at the metal surface.

Disperse particles (probably of ammonium sulphate) play a contributory minor part, as shown by the effect of screening the metal behind muslin.

A series of copper-nickel alloys shows attack proceeding from the copper-rich or the nickel-rich end of the series according as the atmosphere is favourable to tarnishing or to fogging.

18. INFLUENCE OF SOLID POLLUTION (DISPERSE PARTICLES) ON THE RUSTING OF IRON. Exhibits lent by the Chemical Research Laboratory, Teddington.

Rusting of iron is enormously influenced by the presence of disperse particles in the atmosphere. The specimens show :—

- (a) The inhibition of rusting by a simple filtering-out of solid particles by means of a muslin cage. Whilst so screened the specimens develop a film of oxide which tends to prevent rusting on subsequent normal exposure ;
- (b) The development of rusting on specimens that have been previously "inoculated" with traces of certain particles. These may either have an intrinsic effect, as with ammonium sulphate, or they may act by adsorption of traces of sulphur dioxide from the atmosphere, as with charcoal. (A similar process doubtless occurs with carbonaceous particles normally present in the atmosphere.)

In either case the effect is contingent on atmospheric humidity rising above a certain critical value (approximately 80 per cent. of saturation) ; this is shown by means of graphs.

19. INFLUENCE OF GASEOUS POLLUTION IN THE FORMATION OF GREEN PATINA ON COPPER. (An example of a Protective Type of Corrosion Product.) Exhibits lent by the Chemical Research Laboratory, Teddington.

The characteristic Green Patina on Copper is due, in inland districts, to the presence of traces of sulphur dioxide in the atmosphere, together with the influence of rain. In the early stages normal copper sulphate is produced ; this is followed by basic copper sulphate, the basicity of which gradually increases until identity is established with the composition of the mineral brochantite, $\text{CuSO}_4 \cdot 3\text{Cu}(\text{OH})_2$. This process normally occupies a period of about 70 years, after which there is no further change.

At the seaboard basic copper chloride (ultimately $\text{CuCl}_2 \cdot 3\text{Cu}(\text{OH})_2$, *cf.* mineral atacamite) enters into the patina and may predominate if urban conditions are sufficiently remote. The influence of the town normally extends to much greater distances than the influence of the sea ; the direction of prevailing winds in relation to the source of pollution plays, however, an important determining part.

The foregoing points are illustrated by typical specimens and tables showing the results of analyses, together with examples of artificial patina (basic copper sulphate).

20. THE ABSORPTION OF SULPHURIC ACID FROM POLLUTED TOWN ATMOSPHERES AND ITS INFLUENCE ON THE DURABILITY OF LEATHER. Exhibit lent by the British Leather Manufacturers' Research Association.

Pieces of leather cut from books stored in the libraries of different towns are exhibited. The amount of sulphuric acid absorbed by each is given. Those from Aberystwyth, although two or three centuries old, are all in good condition and free from sulphuric acid, whereas those from large industrial towns have absorbed large amounts of sulphuric acid and consequently have rotted in a comparatively short time.

21. LEATHER BINDINGS FROM WINDSOR CASTLE. Exhibit lent by the British Leather Manufacturers' Research Association.

These samples were taken in 1933 with the permission of the Librarian, Mr. O. Morshead.

All three were bound at the same time (1903) with leather from the same delivery ; the first two, which were stored at Buckingham Palace for 10 years, are decayed, and the leather has absorbed 5 per cent. of its weight of sulphuric acid. The third, which had remained at Windsor, has only absorbed 3 per cent. of sulphuric acid and is in much better condition, though showing signs of beginning to decay. The room in Windsor Castle where the leather-bound folios were stored was seldom subject to artificial light so that the atmosphere of Windsor must be the source of the sulphuric acid, though it is evidently much less polluted than that of London.

22. RECORDS OF ATMOSPHERIC POLLUTION IN CERTAIN LIBRARIES, FOR ONE YEAR. Exhibit lent by the British Leather Manufacturers' Research Association.

The figures show the contrast between the high pollution of atmospheres in London libraries and the almost complete absence of pollution in the atmosphere of the Aberystwyth Library.

The figures for pollution of the outdoor atmosphere in Westminster are about ten times those for the indoor atmosphere in Battersea. The figures for the Middlesex Guildhall are remarkably low, the explanation being that circulation of the atmosphere in this underground store is greatly restricted whereas in the Battersea Library the outdoor air has much freer access.

23. PRIZE PHOTOGRAPHS.

The photographs exhibited were awarded prizes or commended in an open competition organised by the National Smoke Abatement Society for the purpose of obtaining photographs of value for propaganda purposes. It will be noted that while most of the prints show smoke emission and the effects of smoke, others stress the value of smokeless conditions, fresh air and sunlight.

24. ATMOSPHERIC DIRT FROM AIR-CONDITIONING PLANT. Lent by E. M. Ackery, Esq.

The importance to health of keeping the air we breathe clean is becoming increasingly appreciated, and most large modern public buildings are provided with an air-conditioning plant whereby a constant supply of clean air at suitable temperature and humidity is maintained. During the cleansing process all solid matter is removed. A typical sample of such solid matter, some of which would otherwise have found its way into human lungs, is exhibited.

25. SPECIMENS OF VARIOUS TYPES OF GRIT AND DUST FROM FURNACES. Lent by Dr. R. Lessing.

Modern industrial furnaces can be operated without production of "smoke" in its true sense, but the high duty they have to perform causes fly-ash and coke particles to go forward from the grate or combustion chamber. Some of this is retained in the flues, but a portion reaches the chimney and is discharged as grit or dust, unless it is previously extracted from the combustion gases in suitable plant, such as :—

- (a) *Cyclones or Grit Arresters*, in which the dust is thrown out by centrifugal force.
- (b) *Electrical Precipitators*, which subject the gases to ionisation in an electric field produced by a current of very high voltage.
- (c) *Scrubbers*, in which the gases are washed with water or an alkaline liquor ; this process permits the simultaneous extraction of the sulphur acids from the combustion gases.

The exhibits show the variation in character and particle size at successive stages of the flue system. Dust is present naturally in coal as mined, and much of it is lifted from the fuel bed and discharged to the atmosphere unburned or incompletely burned.

26. ACID POLLUTION OF ATMOSPHERE. Exhibit lent by Dr. R. Lessing.

All ordinary fuels contain sulphur, which, on burning, forms sulphur dioxide, and, by further oxidation, sulphuric acid. From the coal burned in the London area an average of not less than the equivalent of 1,000 tons of sulphuric acid is emitted every day.

The glass jar (demi-john) exhibited shows the amount of sulphuric acid ($5\frac{1}{2}$ gallons = 20 litres) equivalent to the sulphur acids formed on combustion of one ton of ordinary coal containing 1.5 per cent. sulphur.

27. LINEN EXPOSED TO CITY ATMOSPHERE. Lent by the Corporation of Manchester Public Health Department.

The exhibits consist of two sets of white linen articles, one unexposed and one exposed to the open air in Manchester for 24 hours.

28. FRAGMENTS OF CHIMNEY-POTS. Lent by Lt.-Commander Colin Buist.

The specimens are pieces taken from two chimney-pots of adjoining houses, Nos. 6 and 8, Coniston Close, Barnehurst, Kent. These are new houses, and six months after they had been occupied it was necessary to change the chimneys in consequence of structural alterations. The tenants of No. 6 had used a smokeless fuel made by a well-known process of low-temperature carbonisation through the winter of 1933–34, while ordinary raw coal was used during the same period at No. 8. Both chimneys were therefore in use for the same period. The chimney using low-temperature smokeless fuel was not swept during the winter ; the coal chimney was swept once during the same period. The chimney using the low-temperature smokeless fuel is blackened but there is no deposit. On the coal chimney, however, there is a very heavy deposit, and it must be remembered that this is only a very small part of the soot and unburnt products discharged from the chimney.

The history of this case and a comparison of the two chimneys furnishes a striking illustration of the evils attendant upon the burning of raw coal in the open fire-place.

The blackening of the chimney using the low-temperature smokeless fuel would be partly accounted for by the paper and wood used for lighting the fire, and possibly also by the down-draught from adjacent chimneys.

MEASUREMENT OF SMOKE AND POLLUTION

29. THOMSON AIR POLLUTION RECORDER. Lent by the Manchester Literary and Philosophical Society.

Mr. Wm. Thomson, F.R.S.E., F.I.C., was an active member of the Manchester Air Pollution Advisory Board, which carried out the scientific investigation on the combustion of raw coal and solid smokeless fuels in various types of domestic grates.

Whilst this work was being carried out by Mrs. Margaret Fishenden, and later completed by Dr. Sinnatt, Mr. Thomson constructed in his laboratory the apparatus shown, in order to show graphically the air pollution at various periods of the day, noting at the same time weather conditions which would influence such pollution.

The framed records shown were taken from outside his laboratory in Mosley Street, a quarter of a mile from the Town Hall, and indicated that the air pollution in the centre of such cities as Manchester was mainly due to smoke from domestic fires, such pollution varying with the intensity with which such fires were operated.

30. MEASURING THE DENSITY OF SMOKE IN A FACTORY CHIMNEY.
Model constructed in the Science Museum.

This exhibit is intended to illustrate the way in which the density of the smoke in a factory chimney can be measured and the result indicated on a dial within the factory. The density of the smoke is measured by the amount of light which it cuts off.

A beam of light is projected across the chimney through the smoke and falls upon a photo-electric cell mounted in the wall on the opposite side. The amount of light reaching the cell thus depends on the density of the smoke. The current through the cell, which is proportional to the amount of light falling upon it, is indicated by a meter, which is provided with a special scale indicating the smoke density directly.

In this exhibit, smoke is simulated by a heavy powder suspended in water.

31. SMOKE ALARM EQUIPMENT. Lent by Messrs. Radiovisor Parent, Ltd.

This apparatus is based on the working principles of the well-known Radiovisor Smoke Indicating and Recording apparatus, used extensively in the major Power Stations and many commercial undertakings in this country.

The apparatus is particularly suitable for industrial applications, where for any reason it is desired to obtain an audible or visible alarm when a pre-determined density of smoke, dust or other obnoxious matter is emitted or produced.

The working principle is simple. A light source and light sensitive cell are mounted opposite suitable observing holes in the flue or uptake and used to measure the varying light absorption by the intervening smoke particles. These light variations are converted into electrical currents, which are amplified by a simple valve circuit and used to operate a robust type of relay to give the alarm. Standard apparatus is designed for operation from 200/250 volt 50-cycle supply mains, and maintenance is extremely low.

EXHIBITS LENT BY THE FUEL RESEARCH STATION (Nos. 32 to 39).

32. DETERMINATION OF THE OPACITY OF A COLUMN OF SMOKE.

The instrument used is comprised of a series of tinted glasses, each of which reduces the incident light by the same amount. The patch of sky adjacent to the smoke column in an inclined tube (Exhibit 33) is viewed through the instrument, the observer standing on the ground. Tinted glasses are placed in the line of view until the darkened field seen through the tinted glasses matches that produced by the smoke column. The number of plates required is taken as a measure of the capacity of the smoke. In order to eliminate colour differences both the tinted plates and the smoke column are viewed through a red colour filter.

The method is illustrated by the model. A screen of opal glass, half of which is covered by a fogged photographic plate, is illuminated from behind. The arrangement represents working conditions and the uncovered portion of the screen may be viewed through the instrument, tinted glasses being moved into the line of view until a match is obtained.

33. RELATIONSHIP BETWEEN THE OPTICAL PROPERTIES OF A COLUMN OF SMOKE AND THE WEIGHT OF SOLIDS CARRIED BY IT PER UNIT VOLUME.

Smoke from the fuel burning in the grate passes into the flue, past a sampling head and into an inclined tube mounted on the stack. Here its opacity is measured by the method shown in Exhibit 32. The solid matter carried by the smoke is determined by the method shown in Exhibit 34.

The grate is situated in a room air-tight except for a 6-inch diameter tube passing through an outer wall. The air supply through this tube is measured by means of a vane anemometer. Simultaneous measurements of opacity and weight of solids are taken over a period of 3-5 minutes when the smoke is constant.

34. DETERMINATION OF THE WEIGHT OF SOLIDS IN THE SMOKE.

The dismantled apparatus is shown. A portion of the smoke is drawn through a slot in the sampling head, which extends nearly the full width of the flue and is streamlined to minimise distortion of the gas flow.

The smoke then passes through filter paper supported on wire gauze, which removes the solids, after which the gas is measured by means of a wet meter. The weight of solids is obtained from the increase in weight of the filter paper. The speed at which the gas is drawn through the apparatus must be equal to the linear speed of the gases up the flue, otherwise the flow of gas near the slot is considerably distorted and errors will be introduced.

35. TYPES OF SMOKE PRODUCED BY THE DOMESTIC FIRE.

The domestic fire produces two types of smoke.

1. Distillation Smoke.

A primary distillation product, consisting of low-temperature tarry matter, etc.,

produced during the ignition stages of the fire and immediately on refuelling, and which passes into the atmosphere without combustion.

2. Carbon Smoke.

Free carbon produced by incomplete combustion of hydrocarbon vapours distilled from the coal as shown by a predominance of flames. These are illustrated by the two stains on filter paper.

Apart from their characteristic stain, these types may be distinguished when viewed by transmitted light, the distillation smoke varying in colour from orange to red, while the carbon smoke is a neutral grey.

36. TYPICAL RESULTS.

The graphs show the results of experiments using three good household coals of widely differing properties.

Coal "A."	Strongly caking	...	25.1 per cent. volatile matter.
Coal "B."	Non-caking	...	33.3 per cent. volatile matter.
Coal "C."	Medium caking	...	23.9 per cent. volatile matter.

The weight of solids in milligrams per cubic foot is plotted against the opacity (expressed in the corrected number of tinted glasses), and it is seen that for each coal the points lie, within experimental error, along a straight line.

The weight of solids per unit volume is, therefore, directly proportional to the opacity.

The results shown include both distillation and carbon smoke figures; they are mixed up indiscriminately and cannot be separated into two groups.

37. SMOKE EMISSION FROM A DOMESTIC FIRE.

The graph shows a typical smoke-emission curve obtained from a household coal using the opacity method (Exhibit 36).

In this test 8 lb. of coal, half the quantity required to fill the grate, was ignited by means of gas pokers. When the fire had reached a certain state, 38 minutes afterwards, a further 8 lb. was added. A constant level in the grate was maintained by the addition of 2 lb. charges at 45-minute intervals, starting at 118 minutes from the lighting of the fire.

It is seen from the graph that smoke emission increases rapidly in the early stages of lighting the fire, attains a maximum and then decreases. The addition of a fresh charge increases the emission almost immediately to a high value, followed by a steady decline except for a minor peak coinciding with the outbreak of flames and the production of carbon smoke.

The area under the curves gives the total weights of solids emitted from the separate charges, which in this particular case are 121, 12, 12, 26 and 11 gm. respectively.

38. THE COMBUSTION OF COAL.

For complete combustion, 1 ton of semi-bituminous coal requires 2.62 tons of oxygen or 11.31 tons of air—on a volume basis 27 cu. ft. coal (1 ton) requires 316,000 cu. ft. air.

The theoretical products of combustion of 1 ton of coal are shown, the gaseous products being represented by the volume of the spheres and the weights of solids and liquids by cubes. Of the products, only sulphur dioxide may be regarded as pollution, the ash, theoretically, being retained on the grate.

In actual practice efficient combustion requires the use of 20–25 per cent. excess air, owing to the difficulty of ensuring correct air distribution over the fuel bed. Even so, combustion is not perfect, as some carbon monoxide is formed and some free carbon, tar, etc., are emitted, a light haze being visible over the stack.

A smaller excess of air or uneven distribution results in heat losses owing to unburned gases, and solid matter issues into the atmosphere, a heavy smoke being visible over the stack.

The products of good and bad industrial practice are shown on the same scale as those for theoretical combustion.

39. ATMOSPHERIC POLLUTION PER TON OF COAL, FUEL OIL OR GAS CONSUMED.

The emission of noxious matter into the atmosphere from the combustion of coal, fuel oil, coke or gas is (here) shown divided into its constituents. The weights of polluting material per ton of fuel used are shown as cubes, whose volumes are proportional to the weights. In the first column the sulphur dioxide has been calculated for an average coal containing 1.5 per cent. sulphur, of which about a tenth part is retained in the ash. The last column of water-soluble matter includes mainly ammonium sulphate and chloride. In the case of Battersea Power Station, special de-dusting and sulphur extraction processes are employed to cut down the atmospheric pollution, and it will be seen that only a small trace of sulphur remains. The remaining figures are average values, the actual pollution in any particular case depending on the composition of the fuel and the particular plant in which it is used.

EXHIBITS LENT BY THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL
RESEARCH (Nos. 40 to 53).

40. THE MEASUREMENT OF ATMOSPHERIC POLLUTION.

Eighty-five local authorities and other bodies, a list of which is given, are co-operating in the scheme for the measurement of atmospheric pollution. The places at which observations of pollution are made under the scheme are shown on a large-scale map.

41. DEPOSIT GAUGE.

The deposit gauge is the commonest method for measuring pollution. The gauge is exposed in the open. Sooty matter and dust collect in the funnel and are washed by rain into the collecting bottle. Some of the deposit is dissolved in rain-water and the rest sinks to the bottom of the bottle or remains in suspension. The rain itself also contains soluble impurities which have been taken up by it from the air.

At the end of each month the contents of the bottle and funnel are analysed. The weights of tarry, sooty and mineral matter are determined, as well as the weights of chemical impurities such as sulphur, chlorine and ammonia.

From a knowledge of the area of the funnel, the impurities are calculated in tons per square mile, and the results published in this form.

At present observations are being taken with gauges at the places shown on the map. (Exhibit 40.)

42. TYPICAL SAMPLES OF THE RESULTS OF ANALYSIS OF THE CONTENTS
OF A DEPOSIT GAUGE.

Matter insoluble in water :

"A." *Tar.* This is a particular constituent of smoke and mainly a product of domestic chimneys.

"B." *Carbonaceous matter other than tar.* Besides soot, this includes animal and vegetable dust blown up from the ground.

"C." *Ash.* This includes wind-blown mineral dust, as well as ash or grit which accompanies soot emitted from chimneys.

Matter soluble in water :

"D." *Total dissolved solids.* This is the residue obtained by evaporating the water to dryness. This residue is ignited at a dull-red heat and the results expressed as :—

(1) Loss in weight on ignition.

This represents combustible organic matter, water of constitution and volatile products such as carbon dioxide, ammonium salts, sulphuric acid, nitric acid, etc.

(2) Ash soluble in water.

Sulphates, chlorine and ammonia are also determined separately, because of their special importance.

43. TYPICAL RESULTS WITH DEPOSIT GAUGES.

The diagram indicates the total solids deposited in the twelve months ended 31st March, 1936, at stations for which these results can be compared with general average figures extending over the past five years.

The fact that deposits for particular towns are high does not necessarily imply that proper steps are not being taken to deal with the local problems of pollution. A town which has apparently bad results in its deposit gauge data may be making a serious effort to arrive at a real measure of its local pollution by selecting for its gauges sites at which the deposits recorded are likely to be heaviest.

44. SELECTION OF SITE FOR THE DEPOSIT GAUGE.

The selection of a site for a deposit gauge is of importance. The site should be open and away from buildings and also trees, which, apart from their sheltering effect, may contribute unwanted additions to the deposit. The sound working rule is that the gauge should not be nearer any obstacle than twice the height of the obstacle.

The site should also be free from local artificial pollution of any kind, and should be selected to be reasonably representative of the conditions in the neighbourhood. Gauges exposed in typical situations are illustrated in the photographs.

45. THE AUTOMATIC FILTER.

The automatic filter measures the amount of soot or other black impurity actually floating in the air at a particular period of the day. It thus fulfils a different object from that of the deposit gauge, which measures the impurity deposited during a month. The instrument can give readings at half-hour intervals over a period of a day or two days at a time.

As a vessel filled with water is emptied by the syphon, a definite volume of air is drawn through a special disc of filter paper, and the suspended dust is left behind as a small spot on the filter paper. A clockwork arrangement allows a clean piece of filter

paper to be presented each time the vessel empties, so that at the end of a day's run there are 24 or 48 spots around the filter paper. The spots are compared with a standard scale of shades. It has been found by experiment that the unit of scale of these shades corresponds to 0.32 mgms. of suspended matter per cubic metre of air (*i.e.* 0.54 lb. per million cubic yards). Thus a measure of the polluting matter suspended in the air can be obtained.

Automatic filters are being used at present in the places shown on the map, and typical results obtained with these instruments are also shown.

46. OBSERVATIONS WITH AUTOMATIC FILTER.

These graphs show the monthly variation of suspended impurity during the year ended 31st March, 1936, and give a good picture of this form of pollution at the different stations. While the total amount varies, it is seen that all the graphs show a higher impurity in winter than in summer. This must be attributed chiefly to domestic fires, as the amount of impurity emitted by industrial furnaces would not vary appreciably from summer to winter.

47. SUSPENDED SOOTY IMPURITY (WINTER 1934-35).

These graphs of results obtained from the Automatic Filter show the variation of suspended impurities at the various stations from hour to hour on weekdays (Mondays to Fridays inclusive). There are notable peaks in the forenoon and late afternoon or evening.

The causes of these are at present somewhat uncertain. Both meteorological factors and variations, such as might be expected at morning and evening, in the extent to which smoke is emitted from domestic and industrial chimneys, may be involved.

48. DUST SAMPLING INSTRUMENTS.

There is often need for an instrument which will collect a sample of the dust which floats in the air in such a way that the particle can be examined under a microscope. Many instruments have been devised for this purpose. The two shown have the property of removing all or nearly all the dust from the air drawn through them. Typical samples of the dust collected are illustrated, and diagrams are shown indicating the size of the dust particles making up typical dust samples.

49. THE OWENS JET DUST COUNTER.

By working the handle of the pump 50 c.c. of air is drawn into the barrel, where it takes up water vapour from absorbent paper inside the barrel. Then this damp air is pushed through a narrow slit, where it impinges on a microscope cover-slip. As a result of the expansion of the air while passing through the slit, water condenses on any dust particles, and this helps them to stick to the cover-slip, and a fair proportion of the dust that was in the original 50 c.c. of air is collected in this way. The cover-slip can now be mounted and examined under a high-power microscope.

The Owens Dust Counter has been used to study the spread of pollution from an industrial centre, Norwich being chosen as a centre on account of its comparative isolation from other polluting areas. The results showed that the pollution from Norwich was measurable at distances of 5 to 6 miles from the city. Norwich is about 2 miles across, and a larger industrial area would spread pollution over a much bigger area. For instance, it can be deduced that an industrial area 24 miles across would cause pollution down wind, equal to that at the boundary of Norwich, 35 miles away, and that the polluting cloud caused by it would be 20 miles wide. Pollution from such an area would be detectable at distances of 60 to 70 miles away.

50. THERMAL PRECIPITATOR.

This instrument depends on the remarkable fact that floating dust or smoke particles cannot come right up to the surface of a hot body, so that around a heated wire there is always a space of one-tenth of a mm. or so into which particles do not penetrate. If air is drawn slowly through a narrow cleft which is not quite blocked by an electrically heated wire the air molecules can pass through freely, but no dust or smoke particles can get through. Thus the particles are deposited on the walls of the cleft. This is the principle of the thermal precipitator, and it has been shown that no dust or smoke escapes the instrument at all. In the actual instrument the walls of the cleft are lined with thin glass discs, which can afterwards be removed and the deposit examined under a high power microscope.

51. APPARATUS FOR MEASURING DUST AND SULPHUR DIOXIDE.

Two of the most important constituents of the air from a pollution point of view are dust and sulphur dioxide. The apparatus shown measures dust by the same method as the automatic filter, but it limits itself to obtaining one large stain per day. The blackness of the stain in this case is measured by a special optical method from which the weight of dust in the stain can be determined.

An electrically driven pump draws the air through the filter-paper and an ordinary gas meter measures the volume of the air drawn through, so that the concentration of the dust in a given volume of air can be calculated. It is usual to pass 60 cubic feet of air through the apparatus each day. After being cleaned of dust, the air bubbles through a solution of hydrogen peroxide. Any sulphur dioxide in the air reacts with this solution to form sulphuric acid. At the end of the day's run, the quantity of sulphuric acid in the solution is determined and the concentration of sulphur dioxide in the air deduced. The stations at present measuring sulphur pollution by the volumetric method are shown on the map (Exhibit No. 40) and some diagrams indicating the results are also exhibited. In most cases, the observations are not made in conjunction with the dust-sampling attachment, but at Sheffield combined records are taken and the stains obtained each day during December, 1935, are shown.

52. LEAD PEROXIDE GAUGE.

This instrument measures the "activity" of the air by reason of its pollution by sulphur dioxide. Under a rain shelter is a porcelain cylinder coated with lead peroxide. This is left in the open air to represent the object exposed to attack. Any sulphur dioxide which it meets is taken up and reacts to produce lead sulphate. At the end of a month the coating of the cylinder is removed and the weight of lead sulphate in it determined. The stations making observations with this instrument are on the map (Exhibit 40) and some diagrams of the results are also exhibited.

53. DIRECTIONAL LEAD PEROXIDE GAUGE.

The "activity" of air may depend considerably on the direction in which the wind is blowing. For example at some places an east wind may contain much more sulphur dioxide than a S.W. wind. On the other hand the S.W. wind usually blows more often, and the total sulphur dioxide brought by it in one month may exceed that brought by the east wind.

The upper part of this instrument is an extension of the idea of the simple lead peroxide gauge, so that the "activity" of the different winds which blow can be sorted out. The weather vane exposes an eighth of the lead peroxide surface. As the wind changes direction, different parts of the lead peroxide surface are exposed. At the end of a month this surface is analysed in eight sections, one for each of the winds: N, N.E., E., S.E., S., S.W., W., N.W. The "activities" of the eight winds are then known, and can be shown in such a diagram as those exhibited.

The lower part of the instrument is a wind counter. It counts the number of five minutes for which each of the eight winds has blown during the month's exposure. Every five minutes the electric-clock motor completes an electrical circuit, and one point is registered to the wind which is then blowing. The advantage of this contrivance is that an average "activity" of each wind can be obtained.

EXHIBITS LENT BY METEOROLOGICAL OFFICE.

54. DIAGRAM SHOWING LONDON'S LOSS OF SUNSHINE OWING TO SMOKE.

The curves show the average daily duration of sunshine at three London stations, compared with the mean of three country stations around London. The aggregate loss in the yearly total amounts to 99 hours at Kew, 233 hours at Westminster and 340 hours in the City. The percentage losses of annual sunshine and of winter sunshine are also illustrated.

55. DIAGRAM SHOWING THE PROGRESS OF SMOKE ABATEMENT BETWEEN 1881 AND 1936 REVEALED BY LONDON'S SUNSHINE.

The graphs represent the average sunshine recorded in Central London (mean of City and Westminster) in successive 5-year periods, expressed as a percentage of the sunshine recorded at Kew Observatory. During 1881 to 1935 the loss in summer months (June and July) has been reduced from 16 per cent. to 2 or 3 per cent., and that the loss in winter months (January and December) has been reduced from 80 per cent. to about 50 per cent. At Kew itself the loss as compared with neighbouring country stations is about 15 per cent. in winter and about $3\frac{1}{2}$ per cent. in summer.

56. THREE DIAGRAMS SHOWING THE VISIBILITY AT A CLOSE NETWORK OF STATIONS IN ENGLAND AND WALES ON FEBRUARY 13TH, 1936, AND THE EFFECT OF THE SMOKE OF CONGESTED AREAS ON THE VISIBILITY.

The comparison of these three figures brings out very forcibly how intimately the visibility is associated with smoke.

London on that morning was a black spot, but it is noticeable how rapidly visibility improved in the south-east of England, where the population is less dense. There was a large area of dense fog in the Leeds-Sheffield area, and Manchester, Birmingham, Newcastle and Hartlepool each had their own gloom. Even Norwich had a little patch of dense fog, with foggy conditions extending a little way outside. It is, however, noticeable that the Welsh coalfield and the Bristol area were comparatively clear, though Swindon achieved a dense fog patch of its own. In contrast with the industrial areas, East Anglia, though within the central portion of the anticyclone, was free of fog, and the same was true of most of the counties south of the Thames, except where they were affected by London smoke. Visibility in Wales was almost uniformly above 2,200 yards.

Even leaving aside those places where visibility was very bad, such maps as these must impress how the smoke from densely populated areas is spread over the countryside, and by contrast between East Anglia and the Midlands it is clear we must often bring down fog artificially even on country districts.

57. TWO ILLUSTRATIONS SHOWING THE METHOD OF PRODUCTION OF HIGH FOG AND ITS EFFECT IN LONDON. Lent by the Meteorological Office.

The diagram illustrates the formation of high fog. The smoke of chimneys ascending and carrying its pollution into the layer of cloud above is shown pictorially. In the small diagram of this illustration is shown the distribution of temperature with height observed by means of an aeroplane on a certain day (November 25th, 1927). The vertical temperature gradient up to about 2,400 feet was very nearly the adiabatic lapse rate (the temperature falling off about $5\frac{1}{2}^{\circ}$ F. per 1,000 feet), in which condition the smoke could easily ascend to 2,400 feet; above that height on that day there was an inversion of temperature (the temperature increasing with height to 3,000 feet), in which condition the smoke could not penetrate higher than 2,400 feet. Hence, as is illustrated, it was held down below that height and spread out horizontally. The result is shown by the photograph, taken at midday on that day and showing all the lights of the offices in Kingsway burning as though it were night, while a black pall hung over the sky.

ABATEMENT

EXHIBIT OF MODELS SHOWING HOW SMOKE IS PREVENTED IN INSTALLATIONS BURNING BITUMINOUS COAL (Nos. 58 to 66).

ORGANISED BY THE COAL UTILISATION COUNCIL AND THE COMBUSTION APPLIANCE MAKERS' ASSOCIATION

All carbonaceous fuels, whether solid, liquid or gaseous, are liable to produce smoke if incorrectly burned. This can result from failure to supply sufficient oxygen at the right zone for complete combustion, or from the decomposition of hydrocarbons resulting in a deposit of carbon which will not re-ignite if the gases have passed out of a zone sufficiently well supplied with oxygen and hot enough to burn it. With bituminous coal, smoke may also result from tarry hydrocarbons directly distilled from the coal. All these causes of smoke can be eliminated by proper attention to the method of feeding the coal and the provision of the right quantity of air at the right points to ensure complete combustion.

58. This model demonstrates the effect of insufficient air supply. It consists of a scale model of a chimney stack with a combustion chamber in which a small lamp is burning and a damper for controlling the air supply. When the air supply is reduced, smoke immediately issues from the stack.

59. This wall-diagram by the Fuel Economy Committee of the Federation of British Industries indicates how loss of heat may be prevented in hand-fired boilers. Particular attention is drawn to instructions 2, 3, 4 and 8.

60. This is a model of an appliance especially applicable to large installations ranging from steam output of 50,000 lb. up to 400,000 lb. of steam per hour per boiler. It is the travelling- or chain-grate stoker, the operation of which is to feed the coal in from the front of the fuel bed and carry it slowly forward into the zone of combustion in such a way that it is ignited and burns from the top of the bed downwards. The initial stage of combustion is shown at AA, where the cold fuel from the hopper feeds on to the travelling grate. A plane of ignition BB starts at a short distance from the point of entry of the coal, and a set of processes is initiated which ensures that the products of distillation of coal are ignited before leaving the fuel bed. The lowest black layer contains uncarbonised coal, the red layer consists of coal which is being coked whilst the volatiles are distilled off and passed through the yellow layer, which consists of incandescent coke at such a temperature as to prevent polymerisation of the hydrocarbons. The

orange layer consists of hot ashes, from which all carbonaceous matter has been burnt out, which are deposited in the ash hopper as the grate moves forward. To promote combustion of the various gases produced in the fuel bed, secondary and tertiary air are introduced in suitable quantities at various points of the combustion chamber and in such a manner to ensure their proper mixing and prevent decomposition, with resulting deposition of soot. A travelling-grate stoker working at proper load and with correct adjustment will discharge from the combustion chamber gases entirely free from any smoke-producing residue.

61. This model shows an example of the method of feeding fuel to vertical and sectional boilers. The screw type underfeed stoker sets up a series of zones similar to those of the chain-grate stoker, but lying vertically one over another instead of in advancing layers. Successive zones of combustion are similarly coloured to those on the chain-grate stoker. Underfeed stokers are used for combustion ratings from as low as a few pounds of coal per hour up to nearly half a ton.

Modifications of this principle are seen in the illuminated diagram of a Hodgkinson Coking Stoker applied to a Lancashire Boiler. In this case, the fuel is ignited at the front of the furnace where the heavy volatiles are released, passing over an incandescent fire, thereby being consumed and giving entirely smokeless combustion. The fire doors remain closed during operation and the grates are self-cleaning, giving entirely automatic firing.

There are other systems of automatic firing of bituminous coal which enable smokeless combustion to be obtained.

An alternative method of burning coal without the emission of unburnt residue from the chimney is by firing the coal in the form of powder.

62. This model shows Barking Power Station Boiler House, built by International Combustion, Ltd., one of the largest in this country fired with powdered coal. It contains ten boilers, fired on the Lopulco system, each of 180,000 lb. per hour maximum evaporation. The plant has been in operation since 1928, burning bituminous coal in powdered form and has maintained a high and consistent level of performance.

With powdered coal firing, owing to the fineness of the original particles of coal, the ultimate ash residue contains a proportion of very fine dust, which can be carried into the chimney-stack. To prevent this from passing into the atmosphere, the gases are cleaned by pneumatic means, or by washing, or by electrostatic precipitation.

63. This model illustrates the method of flue-gas treatment employed at the Battersea Power Station. The flue gases are subjected to water sprays and catalytic action of iron oxide, which converts the sulphur dioxide into sulphuric acid, the latter being removed by an alkaline wash, with a result that the discharge from the chimneys is almost invisible and entirely innocuous.

Other methods of flue-gas cleaning are illustrated in Nos. 64, 65 and 66.

64. This diagram shows the complete Howden-I.C.I. system of non-effluent gas-washing plant, including the two liquor circuits: first the main washing liquor recirculating circuit and secondly the purge circuit. The purge is clarified by the filters and returned to the washing liquor circuit. All that leaves the plant is the dust extracted from the gases and the solids formed by neutralisation of the absorbed sulphur.

65. This model illustrates the Buell Micro-Lector Dust Separator using double cyclones, which successively throw out the coarser grains and the finer particles from the gases by centrifugal action. Dust-laden air enters the Primary Separator at A, a concentrated mixture of air and dust is scooped into the Secondary Collector at B. The dust is deposited in collector C and the air discharged through pipe D into Clean Air Outlet drum F, where it joins the clean air from the Primary Separator through the vaned outlet G to the fan H.

66. This diagram illustrates the Sturtevant Electrostatic Precipitation plant for flue-gas cleaning. The gases pass up a cylindrical chamber, at the centre of which is a wire of a very high electrical potential, which can be as high as 150,000 volts as against the walls of the cylinder. This causes each individual particle of dust to become electrified and swept to the wall, where it is discharged and falls down the sides into a collecting chamber. This method offers the advantage of dealing successfully with the finest dust and has been applied to a number of super-power station boilers.

EXHIBITS LENT BY THE LONDON AND COUNTIES COKE ASSOCIATION
(Nos. 67 to 69).

67. IDEAL COKE FIRED MAGAZINE BOILER.

This exhibit is an actual boiler of the gravity feed type for hot water or low-pressure steam service.

The boiler shown is the smallest of the series constructed of cast iron in sectional design. The efficiently proportioned flues and low loss of draught between the grate and the smokehood enable the boiler to operate with natural draught at 80 per cent. efficiency.

The large number of boilers of this type now being installed for the service of works, large blocks of buildings, theatres, etc., testifies to their popularity and to the economy of heat production which they allow.

68. CERAC AUTOMATIC BURNER.

This exhibit is an actual burner of the type used for application to any ordinary hand-fired boiler for central heating or hot-water service, and converts the system into an automatically controlled installation, eliminating all attendance other than filling a hopper and the removal of clinker, an operation stated to require but a few minutes each day.

The burner is designed for the use of smokeless fuels and depends upon gravity feeding of the fuel from a hopper provided as a part of the machine. There are no moving parts of any kind excepting a fan, which provides the air for combustion divided into primary and secondary ports. A feature of the design is the provision for the fusion of ash into clinker; so that all ash may be removed in one piece easily and quickly, no fire bars are fitted. The combustion chamber is water-cooled and connected to the water system of the boiler it is serving.

An economy of 30 per cent. in fuel costs with an almost entire elimination of labour is claimed by the makers, with smokeless combustion at all times.

69. GRAVITY FEED BOILER.

This illuminated panel shows the sectional design and construction of steel fabricated boilers of a type now built in sizes up to two million B.T.U. per hour.

This exhibit well illustrates the gravity-feed principle of fuel feeding from a hopper built integrally with the boiler and feeding fuel to the grate at the same rate as it is consumed. The absence of moving parts and the simplicity of construction are notable, the unit depending solely upon natural draught and well-designed gas passages for its operation. Long periods of operation at high efficiency and without attention are claimed for this design.

Coke is used as a fuel, so that combustion is smokeless and control is automatically arranged by thermostats in any desired combination.

70. MODEL HOUSE SMOKELESSLY HEATED BY GAS AND COKE. Lent by the British Gas Federation.

This model shows how the Gas Industry would put a completely smokeless installation in a £2,000 house.

The main warming of the house is by coke central heating which will effectively keep the temperature constant in the hall or living rooms. The heating will also pleasantly warm the garage in winter and prevent freezing troubles—a great boon to the motorist.

It will be impossible for the house to become too hot and stuffy, because every room is fitted with a thermostat, which, although hidden from view, controls the warmth of the room to whatever degree of heat is required.

For subsidiary heating and for use during the changeable spring and autumn weather, modern coloured gas fires, which are self-lighting, are installed in all rooms except the lounge. Here there is a coke fire which is gas ignited, thus saving time and the labour of laying the fire with wood and paper.

An up-to-date coloured enamel cooker and a gas-operated refrigerator form part of the kitchen equipment.

Hot water is immediately available at all taps from a gas storage water heater. This system also heats the towel rails in the bathrooms.

71. MODEL HOUSE SMOKELESSLY HEATED BY ELECTRICITY. Lent by the Electrical Development Association.

The use of electricity in the home—for room heating, water heating, cooking and washing—eliminates smoke.

The model illustrates a typical smokeless electric house. Various alternative methods of room heating and water heating are shown, all being applicable to new and existing houses.

The chimneys and fire-places, illustrating the application of electric fires in an existing house, are not required in a new building.

72. MODEL HOUSE SMOKELESSLY HEATED BY SOLID FUEL. Lent by The Monmouthshire and South Wales Coalowners' Association.

This model shows how a modern house of approximately £2,000 value would be heated entirely by solid fuel.

For the lounge, a modern open fire is used, together with a twenty-section 30-inch radiator, and for the stair-hall a twenty-section 30-inch radiator. Heated towel-rails are fitted in the bathrooms and a three-section wall radiator heats the garage.

Modern open-hearth fires provide the heating for two bedrooms, and two further bedrooms and the dining-room are heated by means of closed or open stoves, which maintain an equable temperature day and night. The maid's sitting-room is heated by means of an open fire, and the kitchen is equipped with an anthracite cooker which is always ready, as the fire burns day and night. This cooker also provides hot water services for domestic use and for the bathrooms. A boiler in the kitchen also provides the central heating system for the radiators, and an auxiliary domestic hot-water supply for emergency purposes.

The heating appliances shown in the house are models of the following : Devon Fire, Bell Fire, Holmer Fire (2), B. J. Esse Stove, Cozy Stove, Tortoisette Stove, Super Kooksjoie Cooker, Ideal Boiler, Radiators, Combined Radiators and Towel-Rails.

**EXHIBITS LENT BY THE LONDON AND COUNTIES COKE ASSOCIATION
(Nos. 73 to 83).**

73. HOT WATER RADIATOR.

The four column radiator is a typical construction of modern cast-iron design for either hot water or low-pressure steam heating. Connected to the domestic boiler hot-water service, the radiator forms a useful and economical system of partial heating in the small house.

74. MODEL COKE-SCREENING PLANT.

The preparation of coke for the various purposes for which it is used entails separating it into sizes which are suitable to the appliances in which it is burnt. The screen shown in this exhibit is of the horizontal reciprocating type frequently used in modern coke plants for this purpose. The model is operative and coloured beads of various sizes are used in place of coke to show the action of the screen in segregating.

75. COKE SAMPLES.

Coke samples are exhibited of the four standard sizes normally marketed in South England ; these four sizes have been found to be adequate for all purposes of coke application and an extension in the use of these standards is anticipated. The quality improvement in coke has been marked in recent years, and the increasing demand for coke as a domestic fuel is probably consequent upon its better quality and improved preparation. The samples are typical of ordinary gas coke, of which nearly three million tons is sold in the Greater London area each year.

76. IGNITION TEMPERATURE.

Ignition temperature of coke is demonstrated in a small electric furnace into which coke is placed and air passed through it at a uniform rate of 0.02 cu. ft. per minute. The ignition point in coke is of importance, as it determines the amount of heat necessary to bring a coke mass (as in a fire) to a point when it will continue to burn without assistance. A low ignition point is of advantage for Open Fires and a high ignition point is preferable for Hopper Feed boilers.

77. DETERMINATION OF CALORIFIC VALUE.

This exhibit shows the apparatus in which the heating value of coke is determined. In the bomb calorimeter which contains oxygen at 25 atmospheres pressure, a known weight of coke is ignited.

The heat liberated is obtained by measuring the rise in temperature of a known weight of water, in which the bomb is immersed. The calorific value of the market grades of good coke lie between 12,500 and 13,000 B.Th.U. per lb.

78. C.A.B. TEST.

The C.A.B. test for the combustibility of coke is demonstrated in an apparatus employing the method of Bladen and Riley, of the Northern Coke Research Committee. The test is particularly useful in the control of the quality of the coke for open fires ; the desirable C.A.B. value for this purpose is between 0.055 and 0.060 cu. ft. per minute.

79. COKE-FIRED GAS-IGNITED DOMESTIC HOT WATER BOILER.

This exhibit is an ordinary domestic boiler of a type (approved by the London and Counties Coke Association) which is so popular for hot-water service in the home. It has a rated output of 20,000 B.Th.U. per hour and is capable of a 60 per cent. overload for quick service of hot water. Coke boilers of this type are being installed in new houses at the rate of 200,000 units a year, each having a potential coke consumption of three tons of coke per annum. Ignition of the coke is by fitted gas burner or gas poker, for which provision is made in most of the modern designs.

80. AERATED-FLAME GAS POKER.

Aerated-flame gas poker of the design normally used for igniting the fuel in domestic coke boilers or for open fires which are not fitted with permanent gas ignition devices. The use of gas pokers eliminates the labour of setting fires in the old way with paper and sticks, and the gas so used does not make the ignition of the fire more costly than the use of ordinary fire lighters.

81. GAS-IGNITED OPEN COKE FIRE-GRATES.

This exhibit is an ordinary design of insert fire-place for the use of coke, the wider spacing of the bars for coke burning will be noted, as also the means of effective air control to the fire. The popularity of the coke burning fire is evidenced by the number which are being installed; over 70,000 per annum are being supplied in the London area alone. These fires are smokeless in operation and represent a very important and progressive contribution to smoke abatement.

82. DETERMINATION OF VOLATILE MATTER.

This exhibit demonstrates the method employed by the Gas Light and Coke Company for the determination of the volatile matter content in coke.

From the aspect of smoke emission the volatile matter content in solid fuel is important, but in coke the percentage is so low that smoke emission is practically non-existent. The presence of volatiles in small proportion is, however, of advantage in making for easy ignition.

The conditions of coal carbonisation are now so controlled as to permit the desirable percentage of volatiles to remain in the coke.

83. THERMOSTATIC CONTROL FOR COKE-FIRED BOILER.

This exhibit consists of a panel mounting typical equipment employed for the automatic control of heating systems, boilers and calorifiers. The science of remote and automatic heat control for central heating and hot-water systems has made considerable headway in recent years, and a great variety of apparatus and methods are now employed, of which this exhibit is but one example. Coke-burning boilers are now automatically controlled in their heat output with equal facility to boilers using liquid and gaseous fuels.

EXHIBITS LENT BY THE BRITISH GAS FEDERATION (Nos. 84 to 98).

The Gas Industry has a valuable contribution to make in the reduction of smoke and corrosive substances which enter the atmosphere.

In a year 15½ million tons of coal are carbonised in England and Wales, and 1,273,000,000 therms are burnt by 9,400,000 consumers.

This huge quantity of gas is purified by the removal of tar, which is prevented from entering the atmosphere and is used for road dressing. About 8 lb. of sulphur are recovered per ton of coal carbonised and all the ammonia is removed from the gas. The combination of this ammonia with this amount of sulphur would release about ¼ million tons of ammonium sulphate into the air if not prevented. Instead this amount of agricultural fertilizer is made available.

During the purification, benzene and many other by-products are also recovered.

When purified the gas is colourless and burns without smoke. It is employed for all manner of purposes, from furnaces to refrigeration, and from gas fires to water heating under conditions of complete safety and control.

The exhibit is divided into four sections, which demonstrate :

- (a) The constant quality of gas and the precautions taken to ensure a constant heating capacity and freedom from impurities.
- (b) The control exercised during the design of an appliance to ensure that the gas is completely burnt on one hand and that no unnecessary heat is lost with excess air on the other.
- (c) The precautions taken during design to ensure that the maximum possible proportion of the available heat is made use of.
- (d) The inherent controllability of gas.

Control of Quality.

84A. BOYS'S CALORIMETER.

Gas is sold on its heating value but measured in the domestic meter by volume. It is necessary, therefore, that every unit of volume should have a constant heating value. The constancy of the figure for the calorific value is guaranteed by law.

The heating or calorific value of the gas can be measured by means of a Boys's Calorimeter, an example of which is shown. The volume of gas is measured by the meter and is burnt in the inner chamber of the calorimeter, where it heats a stream of water. The rise in temperature of the water is read, and together with the volume passed gives an accurate measure of the calorific value.

84B. THOMAS'S CALORIMETER.

A continuous method of measuring the calorific value is more convenient to provide a check on the gas-making processes. One type of instrument giving a continuous record is the Thomas Calorimeter. In this case a measured volume of air is heated by the burning of a measured volume of gas, and the temperature rise is indicated by means of resistance wires set in the arms of a Wheatstone's bridge. The bridge galvanometer is then so arranged that the deflection is a measure of the calorific value, and a moving chart records the figure. A length of one such chart is shown (exhibit No. 86).

85. DEMONSTRATION OF THE PRINCIPLE OF THE THOMAS CALORIMETER.

A set is here arranged to demonstrate the principle of the Thomas Calorimeter. The air passing up the tube is heated by the small flame and the galvanometer deflection measures the difference in temperature of the resistance wires at the top and bottom. When the button at the front of the bench is pushed, gas of higher calorific value feeds the flame and more heat is generated in the tubes. The temperature of the upper wire is increased and the galvanometer pointer takes up a new position.

86. RECORDS OF CALORIFIC VALUE.

(See description of exhibit No. 84.)

87. PRESSURE OF GAS SUPPLY.

In order to ensure a constant supply of gas by day and night a minimum pressure of 2 in. w.g. is always maintained in the mains, and this figure is legally safeguarded.

In practice a figure higher than this minimum is universal. The local pressure can be seen by depressing a button and reading a pressure gauge.

88. REMOVAL OF SULPHUR FROM GAS.

The whole of the sulphur contained in the hydrogen sulphide which comes over with the raw gas from the retorts is removed by chemical means at the gas works.

The completeness of the removal is estimated by the apparatus shown, which was prescribed by law in 1900.

Lead acetate paper is suspended in the gas stream for 6 hours and should show no darkening after this period. The test will show the presence of five parts per million.

From every ton of coal approximately 8 lbs. of sulphur are prevented from entering the atmosphere by removing it when in the form of hydrogen sulphide.

Control of Combustion.

89. ANALYSIS OF THE PRODUCTS OF COMBUSTION.

In all approved appliances complete combustion of the gas is achieved so that the full heating power of the gas is made use of, and so that no objectionable products are produced. A gas fire is exhibited, so arranged that the products of combustion are collated for analysis.

90. MEASUREMENT OF CARBON MONOXIDE.

If an appliance is improperly made or adjusted, carbon monoxide may be produced; in a sound appliance, however, the gas leaving the flue is considerably freer from this impurity than the air in many London streets.

To ensure sound design the appliance is tested to see what concentration of carbon monoxide is produced.

In the apparatus shown, the gas from a flue is drawn through a purifying train and then over heated iodine pentoxide. The carbon monoxide there releases iodine which is absorbed and estimated.

The test is sensitive to the presence of five parts per million of carbon monoxide.

91. MEASUREMENT OF CARBON DIOXIDE.

If, due to inferior design, excessive air passes through the combustion chamber, heat will be lost up the chimney. During tests on an appliance in the laboratory the concentration of carbon dioxide is measured to indicate the degree of dilution, and therefore the excess air.

The volume of gas before and after the absorption of the carbon dioxide in an alkaline liquid is measured in the apparatus shown.

92. PRODUCTS OF COMBUSTION.

When gas burns completely in air the products of combustion are carbon dioxide and water vapour diluted with nitrogen, in the proportions shown by the model.

Control of Thermal Efficiency.

The highest possible proportion of the heat available in the gas must be made to do useful work in water heating, cooking or refrigeration. This proportion is known as the efficiency.

Measurement of Efficiency.

93. RADIANT EFFICIENCY.

For a gas fire in which most of the useful heat is radiated, a thermopile is used to indicate the thermal efficiency. By means of an apparatus, a model of which is shown, a thermopile is made to scan the hemisphere in front of the fire, and the eighty-one readings together give a measure of the total heat radiated. The figure obtained is compared with the total heat produced during the combustion of the measured volume of gas.

94. DEMONSTRATION OF PRINCIPLE OF RADIANT HEAT MEASUREMENT.

A bowl fire is mounted so that the beam of heat can be made to fall upon a thermopile suspended above it.

The galvanometer deflection is a measure of the intensity of the beam at the thermopile.

95. WATER HEATING EFFICIENCY.

A circulator is shown set up with arrangements for measuring the rate at which gas is burnt, the quantity of water passed and the rise in temperature of this water. The proportion of heat imparted to the water is thus ascertained. Efficiencies of 80 per cent. and over are obtainable.

96. SECTION OF WATER HEATER.

This is a section of the same household circulator, showing the thermostat for cutting down the gas supply when the tank is heated ; central water-carrying tube to which the heat is imparted by the fins at the top ; the burner and combustion space, etc.

Control of Operation.

Gas is very easily controlled in operation by hand or by automatic means.

97. THERMOSTATS.

These are devices to control temperature of ovens on cookers, of furnaces in industrial use, of living rooms or of water in hot water-systems.

A cooker thermostat is shown in operation with a valve, which makes it easier to see the continual control exercised by the instrument upon the gas rate. As soon as the rod is hot enough the gas supply is shut down, and when it has cooled the supply comes on again.

97A. SECTION OF THERMOSTAT.

The working parts of one type are laid open. A central rod does not expand when heated, while its outer tube does. The resulting relative movement opens and closes the valve in relation to the temperature of the rod and tube. The adjustment for varying the oven temperature is obtained by moving the valve further from or nearer to its seating by means of the rotatable knob at the end, and thus altering the relative lengths of the rod and tube when the valve is closed.

98. AUTOMATIC IGNITION OF GAS.

Gas can now be ignited automatically without the use of matches. One method is demonstrated. When the gas is turned on, some passes over the pellet of platinum black in the housing above the mantle, and by burning catalytically on the surface of the pellet raises this to a sufficiently high temperature to cause ignition. The method is applicable to almost all gas-burning appliances.

A demonstration of such a catalyst is shown continually in action.

99. EXHIBITS LENT BY THE BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION.

This exhibit shows pictorially the contribution of electricity towards smoke abatement in various industries. Illustrations of the application of electricity to power production, steel smelting, pottery work, road and rail transport, and building heating are given. Scale models of two different types of electric arc metal melting furnaces are displayed.

100. EXHIBIT OF NATURAL SMOKELESS FUELS. (LENT BY THE MONMOUTHSHIRE AND SOUTH WALES COAL OWNERS' ASSOCIATION).

This exhibit displays a variety of the smokeless coals so abundantly available in South Wales, together with representations of certain of the many proprietary grates, stoves, cookers, etc., for which the coals are pre-eminently suited.

EXHIBITS LENT BY THE LOW-TEMPERATURE COAL DISTILLERS' ASSOCIATION OF GREAT BRITAIN, LTD. (Nos. 101 to 103).

Low-temperature carbonisation is the term generally applied to the process of distilling coal at temperatures ranging from 450° to 600° C. When small coal is carbonised at low temperatures in this way the value of the products is many times that of the original coal.

The process was evolved primarily for the manufacture of smokeless fuel from coal, which it accomplishes by driving off the excess volatile matter, ammonia and water, which together combine to form smoke and lower the radiation efficiency of the fuel.

The raw material used in the majority of processes consists of washed small coal, much of it little more than dust, and the upgrading of this material increases the national wealth to the extent of the difference in value of the raw material and the finished products.

101. SOLID FUEL PRODUCTS.

The smokeless fuel is quite different from the ordinary high-temperature coke obtained from Gas Works and Coke Ovens, and may be used for several purposes. Large-size smokeless fuel is designed primarily for use in the domestic grate. It lights easily, burns up quickly with plenty of flame, radiates great heat and is quite smokeless. No special grate or other apparatus is required.

Another type of this fuel may be used in gas producers adapted for attachment to road vehicles.

Certain types of low-temperature plants specialise in the production of a semi-coke, which is utilised as a lean material for blending with highly swelling coals, the resultant coke being especially useful for metallurgical purposes.

The solid fuel exhibits include samples of washed small coal (the raw material), smokeless fuel for domestic use, smokeless fuel for use in blends in the manufacture of domestic and metallurgical cokes, smokeless fuel for use with a gas producer in transport vehicles, and low temperature pitch.

102. OIL PRODUCTS.

From each ton of bituminous coal there is produced about 18 gallons of crude coal oil, 3 gallons of crude motor spirit and 30 therms of rich gas. The crude coal oil is particularly suitable for further treatment by hydrogenation or distillation, producing refined motor spirit, solvent naphtha, creosote for wood preservation, fuel oil for burning under boilers, also Diesel oil for use in both transport and stationary engines, together with tar acids and other by-products for the chemical industry.

In England, petrol made from coal is in regular use by the Royal Air Force, and quantities of the fuel oil have been successfully used by the British Navy.

The oil products exhibited include samples of crude coal oil, fuel oil, Diesel oil, and refined motor spirit produced by hydrogenation of crude coal oil, Diesel oil produced by distillation of crude coal oil, crude motor spirit and refined aviation spirit.

103. GAS AND CHEMICAL PRODUCTS.

The tar acids may be worked up into a large number of products, including preparations for dipping sheep, liquids for spraying over coffee and rubber plantations to protect

the plants against parasitic growths, powerful disinfectants for use in drainage systems, refined antiseptic preparations for surgical use and many similar purposes.

The rich gas evolved in the process can either be used for heating the retorts or may be distributed for domestic or industrial use. When compressed into steel cylinders at a pressure of about twenty atmospheres it may be used for transport vehicles in lieu of petrol, thereby effecting considerable saving.

The gas and chemical products exhibited include samples of solvent naphtha, high boiling tar acids, disinfecting fluid, shirlacrol, oil-soluble resin, oil varnish made from soluble resin, novolak resin, sulphate of ammonia and cresylic acid.

EXHIBITS LENT BY THE BRITISH OIL BURNER MANUFACTURERS' ASSOCIATION, LTD. (Nos. 104 and 105).

104. TYPICAL BRITISH-MADE AUTOMATIC OIL BURNER DESIGNED TO BURN BLENDED OR DISTILLATE FUEL OIL.

An Automatic Oil Burner of this type is a valuable aid to smoke prevention, as the atomised oil and air supplies are intimately mixed in such a manner as to provide clean, smokeless combustion.

The burner is controlled by means of a room or boiler thermostat and will provide even heating silently and without attention; it is automatically shut down by the action of the control thermostat when the demand for heat ceases and there are no stand-by losses.

There is no smell, dirt, dust, ash or clinker.

105. MODEL BOILER-HOUSE.

Automatic heating with oil fuel eliminates smoke, dirt and dust, and enables boiler rooms and surrounding premises to be kept as clean and tidy as the model exhibited.

106. WEIGHT OF SMOKE PER FAMILY.

A pictorial chart, used for popular demonstration at health exhibitions, showing that the weight of constituents of smoke emitted annually by the chimneys of the average home is greater than the combined weight of the members of the average family. The weights are based upon estimates of the composition and quantities of domestic smoke made by Professor Cohen and Dr. Ruston in "Smoke," and by Professor Bone in "Coal and its Scientific Uses."

107. CHART OF THE EFFECTS OF SMOKE.

108. HISTORY OF SMOKE ABATEMENT.

POSTERS.

109. Part of the poster set published by the National Smoke Abatement Society for use on the poster frames erected by the Empire Marketing Board and now used by local authorities for health propaganda. Issued in conjunction with the Central Council for Health Education.



**BUY BRITISH
LABORATORY
EQUIPMENT**

From the
**PREMIER SCIENTIFIC
HOUSE IN ENGLAND**
Lists Free on Application

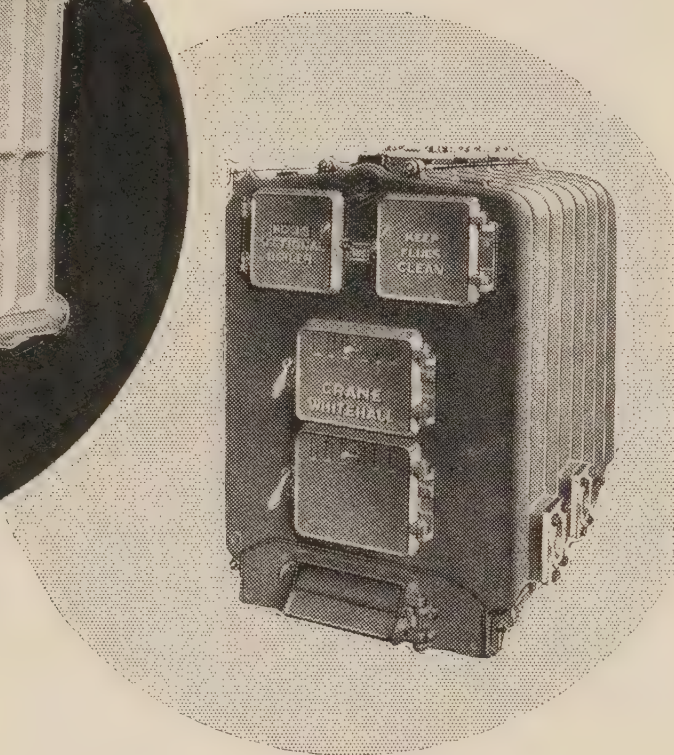
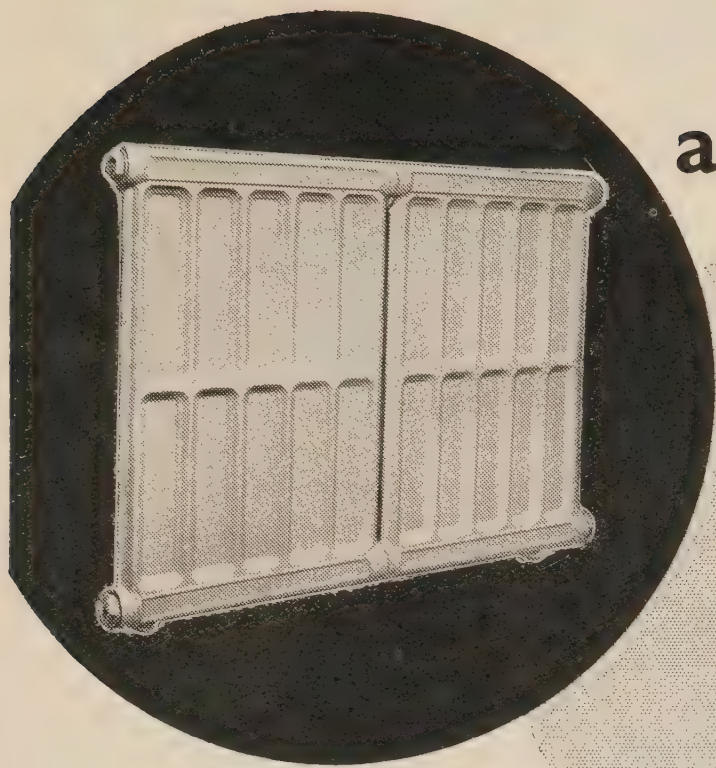
A. Callenkamp & Co. Ltd.

TECHNICO HOUSE
17 TO 29, SUN STREET,
AND
1 TO 3, CLIFTON STREET,
FINSBURY SQ., LONDON, E.C.2.

TRADE *Technico* MARK



The most obvious solution to air-pollution!



The first and most obvious palliative to air-pollution is Central Heating. Its virtue is simplicity. Realising this, Crane have put the virtue into practice in the design of all their heating appliances. Crane Boilers, though often unseen, are as graceful in their efficiency as the most modern Crane "Pall Mall" Radiators.

Many architects and engineers have discovered that by making full use of the enlightened simplicity of Crane designs, they can achieve perfect interior harmony as well as contributing substantially to the purity of the atmosphere in the outside world.

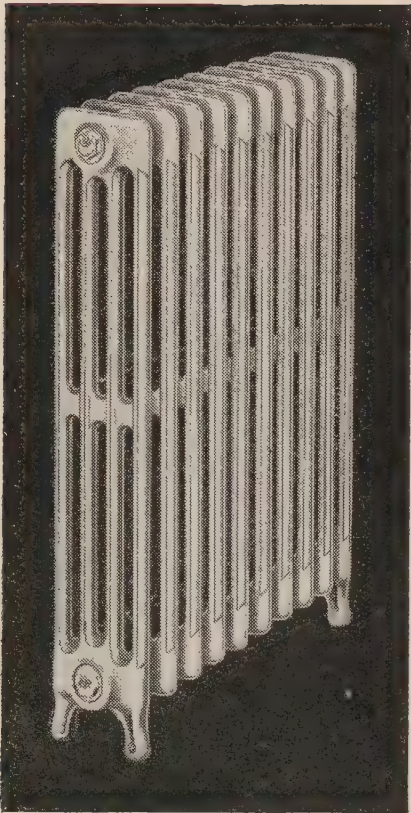
CRANE BOILERS & RADIATORS

CRANE LTD. 45/51, LEMAN STREET, LONDON, E.1
London Showrooms: 118, WIGMORE STREET, W.1

Branches: BIRMINGHAM, BRISTOL, GLASGOW, MANCHESTER. Works: IPSWICH

VALVES, FITTINGS & HEATING EQUIPMENT

IDEAL BOILERS & RADIATORS



Neo-Classic Radiators

Points to be remembered when selecting Ideal Neo-Classic Radiators: they express the results of over 40 years' research, progressive design and manufacturing experience. Rigid tests have proved that they give more useful heat in the living zone—floor to head level—without the use of deflectors. They are of strong construction, neat and unobtrusive in design, easily decorated and kept clean.

No. 4.

Burning coke or anthracite, this type of boiler includes the following features—
 Gravity feed ● Water-cooled, sloping grate—minimum of clinker ● Natural draught ● 80% efficiency ● Right or left-hand magazine ● Top charging door for hopper feed ● Front charging door ● Longer intervals between stoking ● All surfaces accessible for cleaning.

From 148,000 to 1,000,000 B.T.U. per hour.

IDEAL BOILERS & RADIATORS

LIMITED

IDEAL WORKS - HULL - YORKS

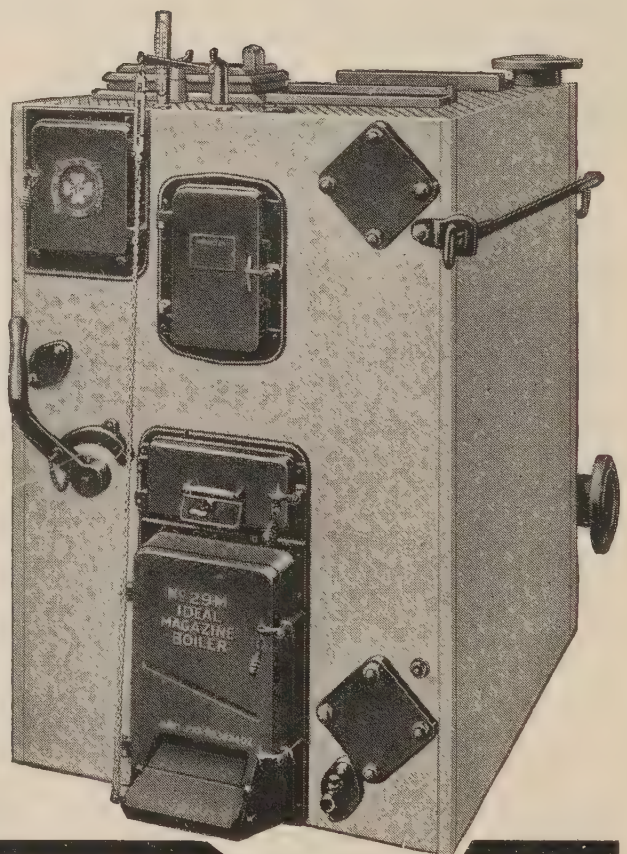
London Showrooms:

IDEAL HOUSE,
 GT. MARLBOROUGH STREET, W.I.

Also at BIRMINGHAM and HULL

MAGAZINE BOILERS

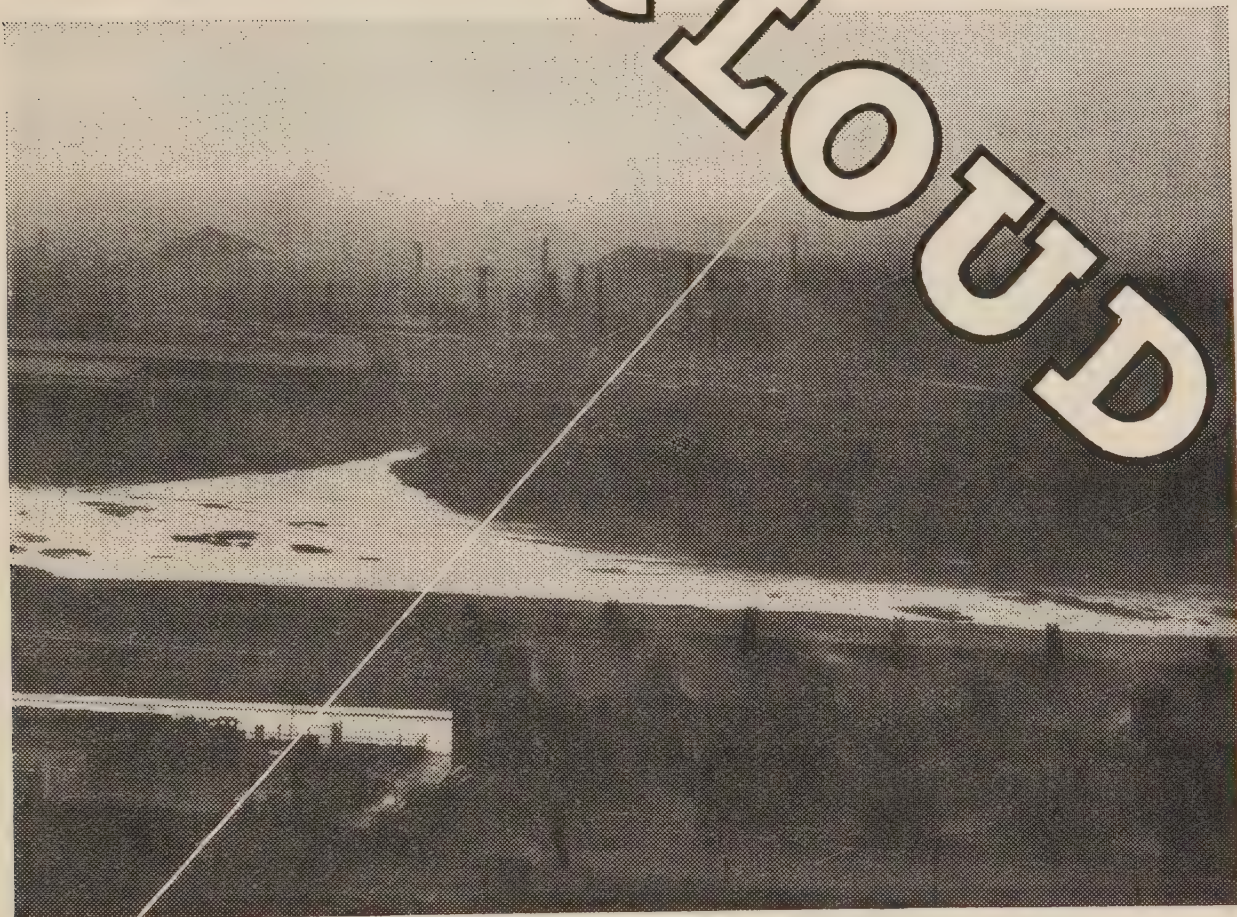
Brit. Patent No. 392402



EVERY INDUSTRIAL TOWN

could abolish
that

CLEAN



★ if crude coal were
replaced by **GAS**

THE BRITISH COMMERCIAL GAS ASSOCIATION
GAS INDUSTRIES HOUSE, 1 GROSVENOR PLACE
LONDON, S.W.1

Public Servant No. 1

BRITISH OIL BURNER MANUFACTURERS ASSOCIATION LIMITED



The aims of this Association are to ensure

Reliability

Efficiency

Smokeless

Combustion

by the use of

Oil Burning Equipment

First class workmanship in design and execution are important points in all branches of engineering.

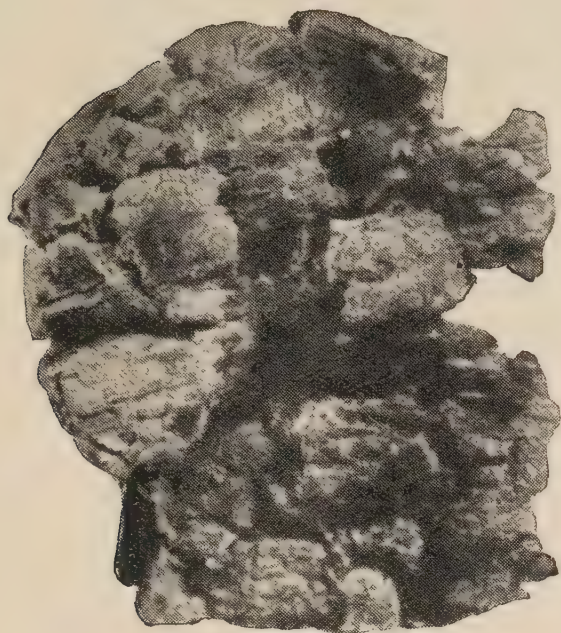
In no branch is this more important than in the generation of heat, upon which so many industries depend.



*Names of the leading manufacturers of
reliable and efficient British oil burners
and auxiliary equipment for all purposes
may be obtained from the Secretary*

British Oil Burner Manufacturers Association Ltd.
69 Cannon Street **London, E.C.4.**

SMOKELESS COAL or SMOKELESS FUEL which?



AFTER COMBUSTION

PHURNO D SMOKELESS COAL

Whilst all Smokeless Coals are Smokeless Fuels—Smokeless Fuels are not Smokeless Coals.



The same piece of coal
BEFORE combustion

Nature's Finished Product IS DIFFERENT

because it combines the maximum amount of heat in a minimum space. It is the most economical form of heating procurable for all types of domestic hot water boilers, slow combustion stoves, central heating plants, and for automatic domestic stokers.



The two Photographs above show the opening out characteristics of Phurno D before and after combustion.

Obtainable from your coal merchant or through

STEPHENSON CLARKE & ASSOCIATED COMPANIES LTD.

Head Office : 4, St. Dunstan's Alley, London, E.C.3.

Telephone : Mansion House 3270 (13 Lines).

*And at Belfast, Birmingham, Hull, Newport, Liverpool,
Nottingham, Southampton, etc.*

“COALITE”

(Regd. Trade Mark)

THE NATIONAL SMOKELESS FUEL *No SPECIAL GRATE REQUIRED*

“COALITE” is made from the best of best coal after it has been washed to remove the ash and other impurities. There is only one standard of quality—the BEST.

“COALITE” burns with plenty of flame, gives out great heat, but does not smoke or form soot.

“COALITE” makes chimney cleaning unnecessary and, of course, decorations and curtains keep clean for a much longer time.

“COALITE” is half the weight of coal thereby providing the users with twice as many scuttles to the ton. It is also easier to carry and cleaner to handle.

“COALITE” is suitable for all types of grate, stove or range. No other form of fuel need be stocked.

“COALITE” is easily lit in the usual way with paper and wood. It makes a magnificent fire at low cost, giving out the most beneficial form of radiant heat.

“COALITE” is a national asset. In the manufacture of “Coalite,” Petrol is produced for the Royal Air Force, Fuel Oil for the Royal Navy, Diesel Oil and other valuable products. By the use of “Coalite,” smoke and fog producing elements are eliminated with a beneficial effect upon the health of the people.

Manufacturers :

LOW TEMPERATURE CARBONISATION L^{TD}.

28, Grosvenor Place, London, S.W.1

Telephone : Sloane 9274.



WELSH COALS for CLEANLINESS and POWER

Welsh coals are clean. Cardiff's Civic Centre, illustrated here and built 30 years ago, is a striking proof of this cleanliness. After all these years, it still looks like a sun-bleached Hollywood "set." Next time you are in the streets of Cardiff, look around you and above you. You will see that Welsh coals are clean.

**WHATEVER YOUR REQUIREMENTS FOR HEATING,
WELSH COALS CAN ACCOMPLISH THEM MOST
ECONOMICALLY, MOST EFFICIENTLY AND MOST
CLEANLY**

**THERE ARE SPECIAL QUALITIES OF WELSH
COAL SPECIFICALLY SUITABLE FOR :—**

- STEAM RAISING - - - *By Hand Stoking, by Chain Grate Stokers, by Retort Stokers, by Any Mechanical means.*
- CENTRAL HEATING - - *By Hand Firing, by Automatic Stoking Plant of all kinds.*
- METALLURGICAL PURPOSES *For Annealing, for Producer Gas Plant, for Suction Gas Plant.*
- COKING COALS - - - *In all kinds of Coke Ovens, regenerative and non-regenerative.*
- FOR LORRIES, TRACTORS
AND STEAM ROLLERS *Of all types.*
- FOR DOMESTIC FIRES - - *Whether closed or open Grates.*

A·A·C

ANTHRACITE



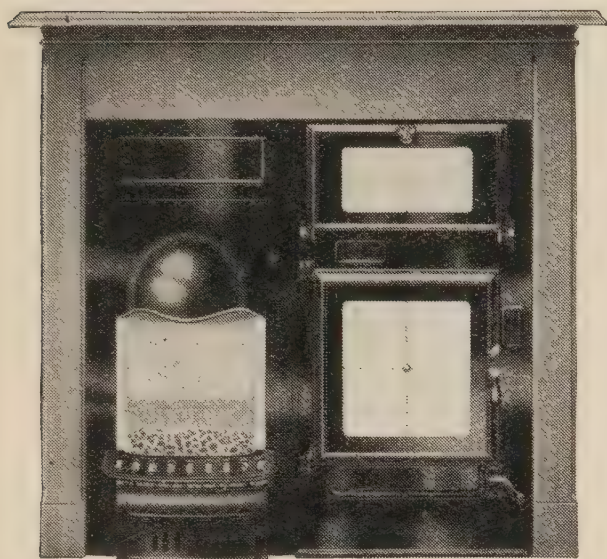
**THE FINEST
SMOKELESS FUEL
FOR ALL PURPOSES**



Enquiries—Write to
**AMALGAMATED
ANTHRACITE
COLLIERIES, LTD.
SWANSEA & LONDON**

NO SMOKE

WITH THE EAGLE COKE-BURNING COMBINATION GRATES

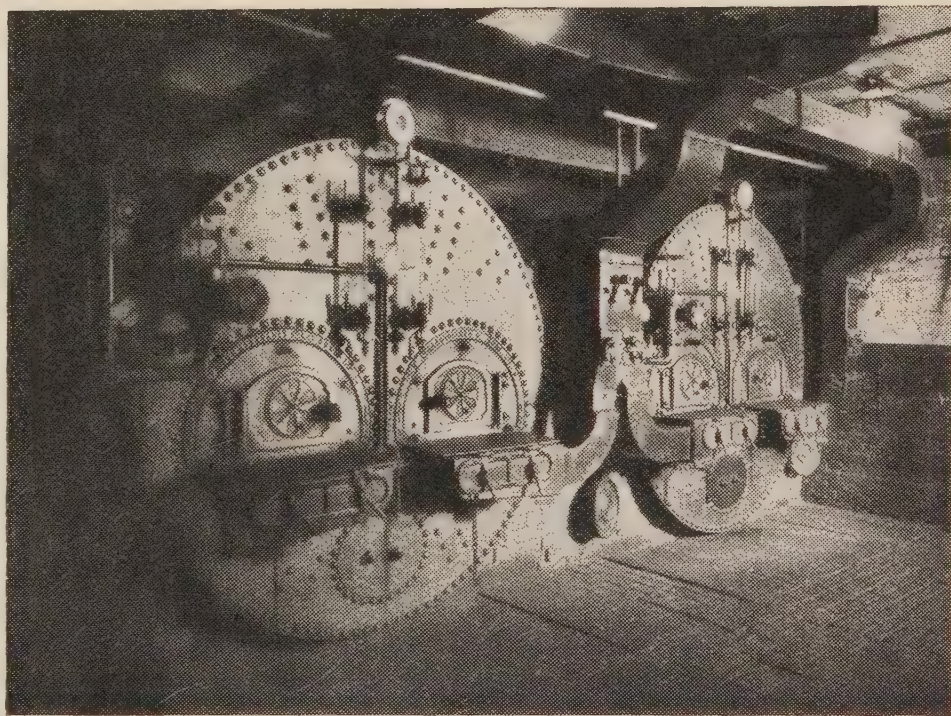


THE Eagle CB.21 Coke-Burning Combination Grate ensures perfect cooking, abundant hot water and a bright open fire at a very low fuel cost. If you are tired of smoke, soot and trouble in lighting fires in your open grates, consider the new coke fires. The Eagle Gas-Coke Grate specially designed for the burning of this clean, cheap, and smokeless fuel reduces cinder to a minimum. The Eagle High-Efficiency Gas Burner dispenses with the use of paper and firewood for lighting. Eagle productions include open fire grates in attractive modern designs for coal burning as well as the Gas-Coke type, and most models are available in durable coloured enamel finishes.

THE EAGLE RANGE & GRATE CO. LTD
ASTON, BIRMINGHAM, 6

Radiation

80%
EFFICIENCY
ON
LANGASHIRE
BOILER
PLANTS

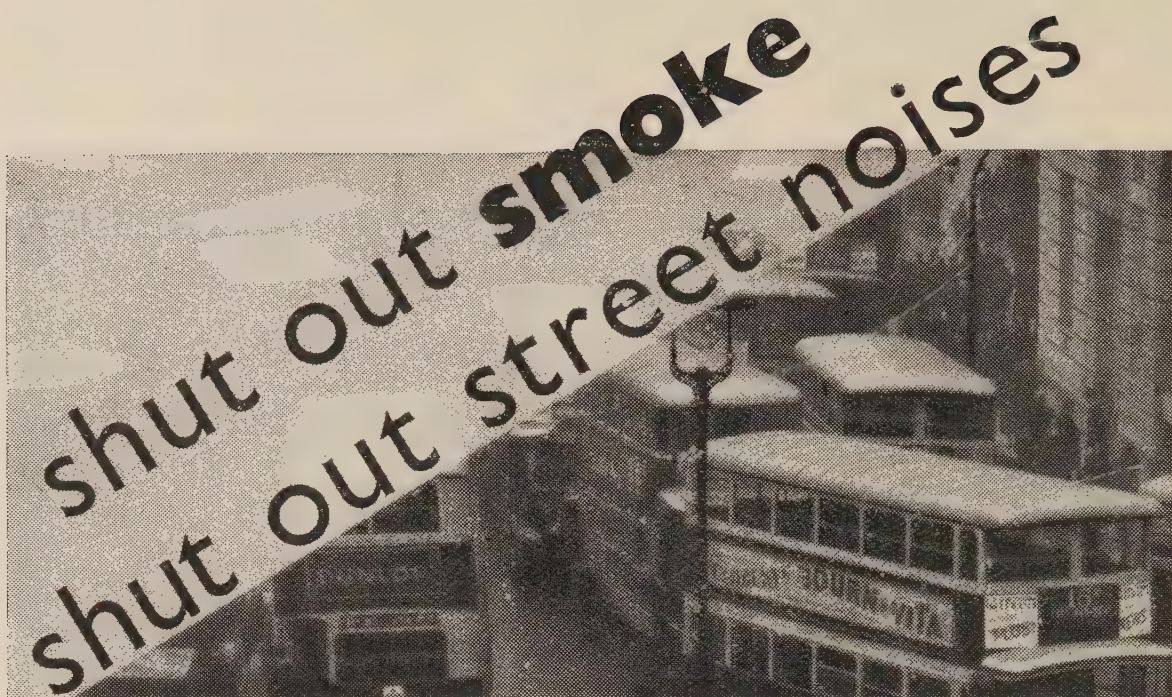


NO BLACK SMOKE

—IS BEING OBTAINED WITH

TURBINE PATENT **FURNACES**

The Turbine Furnace Co. Ltd., 238b, Gray's Inn Road, London, W.C.1.



You can shut out smoke, dirt and street noises by fitting Filteraire to your window. Filteraire is a simple apparatus which ensures a constant stream of *filtered* air (450 cubic feet a minute) in your rooms while the windows remain shut. You are neither stuffy, nor draughty and smothered in dirt, germ-laden dust, soot, cinders and smoke. And you get quiet.

Filteraire does not cure the smoke nuisance. But while waiting for its cure, it does save you from it.

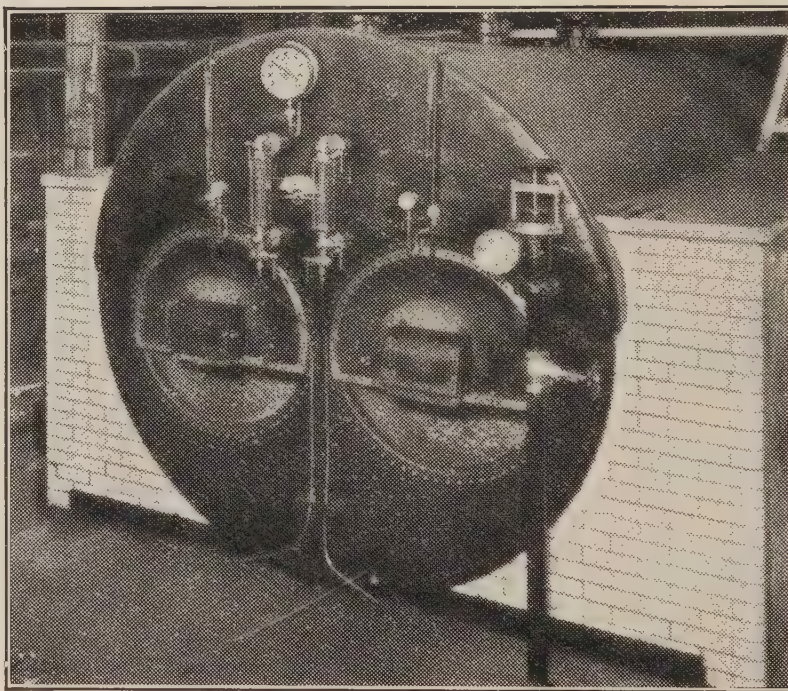
Filteraire can be seen at the Building Centre, 158 New Bond Street, London, W.1, and literature and particulars can be obtained from:—

Tel: Park 7817

FILTERAIRE LTD., 33 Jameson Street, W.8.

SOME USERS

The Admiralty
W. H. Allen, Sons &
Co., Ltd.
Bristol Electricity
Co., Ltd.
British American
Tobacco Co., Ltd.
Distillers Co., Ltd.
Edmundson's Elec-
tricity Supply
Corp., Ltd.
Essex County
Council
H.M.V., Hayes
Huntley & Palmer,
Ltd.
Ipswich Beet Sugar
Co., Ltd.
Ministry of Mines
Peter Brotherhood
Eng. Co., Ltd.



One of three Boilers equipped for Messrs. Westinghouse Brake Co., Ltd.

Improved combustion conditions enabling highly volatile fuels to be burnt entirely without smoke emission. Small capital outlay. Adapted to all types of boilers.

Also manufacturers of Mechanical Stokers and Forced Draught Furnace Equipment, etc.

SMOKELESS COMBUSTION CO., LTD., 265, STRAND, W.C.2

SMOKE ABATEMENT

IT IS NO LONGER AN EXCUSE
THAT THE CHIMNEY CANNOT
BE SEEN

RADIOVISOR INDICATORS & ALARMS

GIVE INSTANT AND EXACT
INFORMATION TO THE
STOKERS

Instal

RADIOVISOR

Smoke Indicators and/or Smoke Alarms

AN UP-TO-DATE
SERVICE

CLEANLINESS
WITH ECONOMY

Apply: **RADIOVISOR PARENT LIMITED**
28, LITTLE RUSSELL STREET LONDON, W.C.1

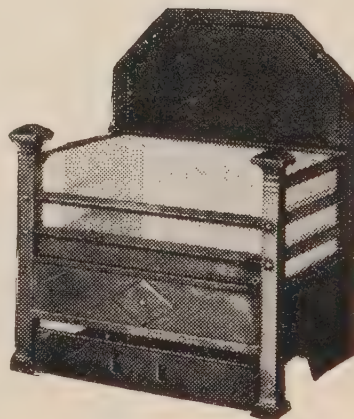
“METRO” COKE FIRES

AWARDED: ROYAL SANITARY INSTITUTE'S PRIZE MEDAL,
INSTITUTE OF HYGIENE'S CERTIFICATE

The Premier Smokeless Fires. Burn household grade coke. Throw out intense heat. Burn with a lively flame. Include gas-burner for starting.

In five distinct types:—

- **INSET** for building-in to existing fire-places.
- **UNIT** slip-in type for modern grates.
- **INDEPENDENT** with flue out at top or back, rendering structural alterations unnecessary.
- **BASKET TYPE** for standing in suitable open fire places. No. 135 is illustrated.
- **MANTEL REGISTER** comprising fire and mantelpiece.



The METRO Coke Fire is manufactured and distributed for the South Metropolitan Gas Company by Sidney Flavel & Co., Ltd., Leamington, and 38 Welbeck St., London, W.1, from whom prices and full information may be obtained.

EXPERT ADVICE ON FUEL, HEATING AND INSTALLATION PROBLEMS

- STEAM RAISING
- HOT WATER SUPPLY
- GLASSHOUSE HEATING
- SMOKE PREVENTION
- CENTRAL HEATING
- GRASS DRYING
- SOIL WARMING
- ORCHARD HEATING

If you are contemplating the installation of heating plant of any description ; if you have a fuel or heating problem ; or if you are not satisfied that you are getting the best out of your existing plant or furnace, write or telephone to the London and Counties Coke Association. Our Technical Department will make a thorough investigation of your special needs, freely and without obligation.

The London and Counties Coke Association gives technical assistance to all users of fuel, to Architects and to Heating Engineers ; its Engineers and Fuel Experts attend personally to advise impartially on installations of plant, to carry out boiler tests and to assist in securing the greatest efficiency. Where Coke may be unsuitable, users are told so, frankly, and an alternative fuel or method is suggested.

THE FOLLOWING AUTHORITATIVE BROCHURES
HAVE BEEN ISSUED BY THE ASSOCIATION
AND WILL BE SENT FREE ON REQUEST

**“MODERN CENTRAL HEATING
AND HOT WATER SUPPLY” ;**

**“FUEL ECONOMY AND SMOKE
PREVENTION” ;** (Steam Raising,
Oven Furnaces and the Art of successful Boiler Firing) ;

“CINEMA HEATING” ;

“SMOKELESS OPEN FIRES” ;

“GRASS DRYING” ;

“SOIL WARMING” (Fruit Growers
and Nurserymen) ;

**“HOW TO SAVE ON FUEL
COSTS”** (Glasshouse Heating) ;

“ORCHARD HEATING” ;

“DOMESTIC BOILERS” ;

And other brochures dealing with every
aspect of Steam Raising, Domestic
Heating and Hot Water Supply.

Write or Telephone :—

THE LONDON & COUNTIES COKE ASSOCIATION
1 GROSVENOR PLACE, LONDON, S.W.1 (Sloane 8266)

**RATIONAL
PLANNING** calls for



ELECTRICITY

See the
EDA
Display
at the
Exhibition

Smokeless power, fumeless heat, flameless light. Cleaner cities, healthier cities, happier people. The day is coming when we shall see all industrial and domestic labour transformed by electrical means.

**Announcement of the British Electrical
Development Association**

2 Savoy Hill, London, W.C.2

Telephone : Temple Bar 9434

**FOR SCIENTIFIC
TREATMENT OF AIR
AND ELIMINATION OF
POISONOUS FUMES
AND SOOT FROM GASES**

CONSULT:

Write for particulars
of the Turner system
at work in varnish
factories for the elimin-
ation of fumes from the
gum-running process.

NORMAN TURNER ENGINEERING Co., Ltd.

121, VICTORIA ST., LONDON, S.W.1

AND AT

**GLASGOW, NEWCASTLE AND
BIRMINGHAM**

LIST OF ADVERTISERS WHO HAVE CONTRIBUTED SPACE TO THE EXHIBITION HANDBOOK OF THE NATIONAL SMOKE ABATEMENT SOCIETY

	PAGE
Amalgamated Anthracite Collieries, Ltd.	72
Ascot Gas Water Heaters, Ltd.	<i>Inside Back Cover</i>
British Commercial Gas Association	67
British Electrical Development Association, Incorporated	77
British Oil Burner Manufacturers Association Ltd.	68
Crane, Ltd.	65
Eagle Range & Grate Co., Ltd.	73
Filteraire, Ltd.	74
Sidney Flavel & Co., Ltd.	75
A. Gallenkamp & Co., Ltd.	64
Ideal Boilers & Radiators, Limited	66
London & Counties Coke Association	76
Low Temperature Carbonisation, Ltd.	70
Monmouthshire & South Wales Coal Owners Association	71
Norman Turner Engineering Co., Ltd.	78
Powell Duffryn Associated Collieries, Ltd.. . . .	69
Radiovisor Parent Limited	75
Smokeless Combustion Co., Ltd.	74
Turbine Furnace Co., Ltd.	73

PRINTED IN GREAT BRITAIN BY
WILLIAM CLOWES AND SONS, LIMITED,
LONDON AND BECCLES.

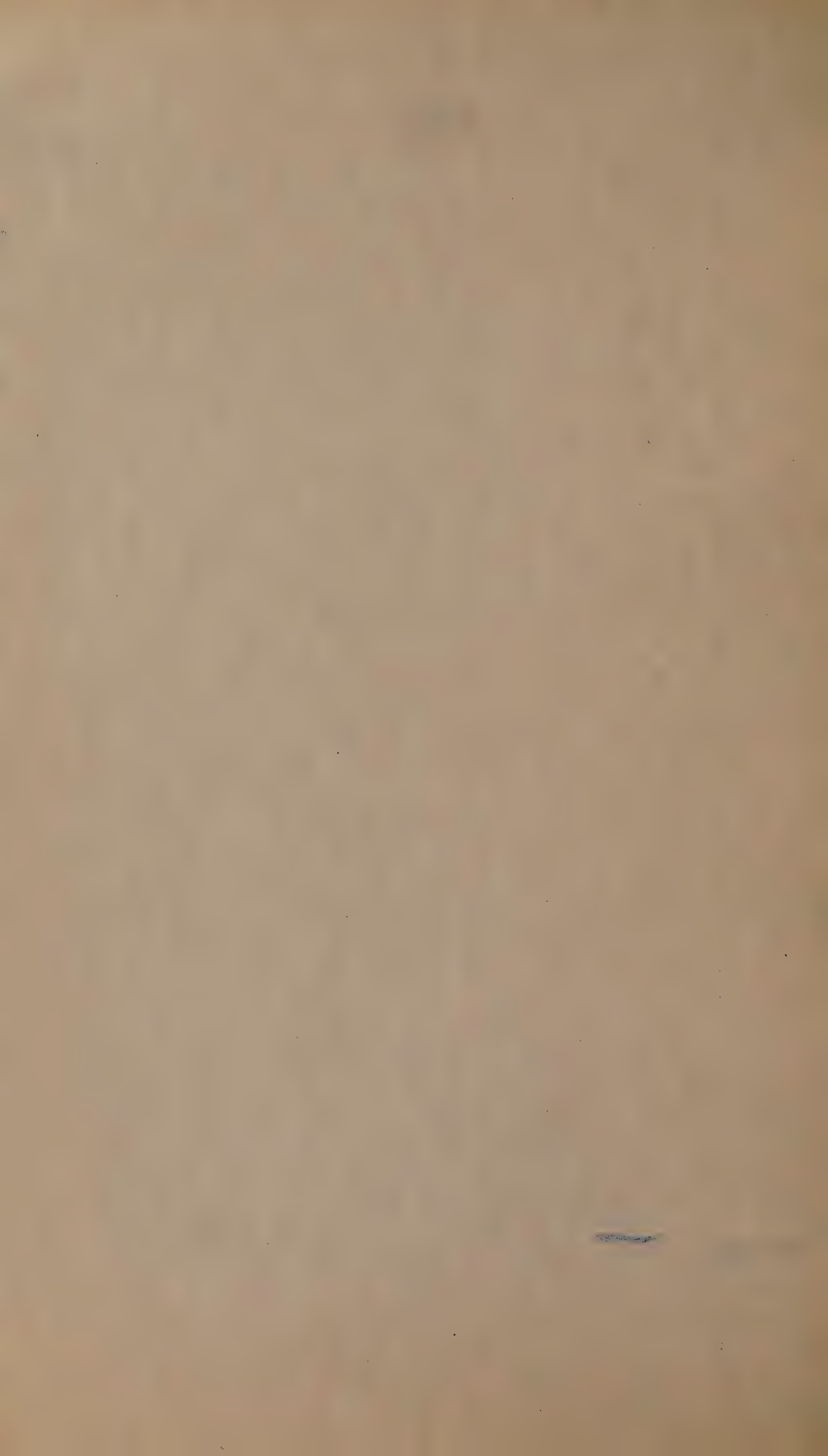
ASCOT

CONSTANT HOT WATER FOR THE MILLIONS



'ASCOT' GAS WATER HEATERS

SUPPLIED ON EASY TERMS BY YOUR LOCAL GAS COMPANY





NATIONAL SMOKE ABATEMENT SOCIETY



Programme of the EIGHTH ANNUAL CONFERENCE



to be held at the

SCIENCE MUSEUM
SOUTH KENSINGTON

(By permission of the Director, Col.
E. E. B. Mackintosh, D.S.O.)

on

October 14th to 17th
1936



in conjunction with the
SMOKE ABATEMENT
EXHIBITION

Open October 1st to 31st

1000000/F/113/1

National Smoke Abatement Society

(Incorporating the Coal Smoke Abatement Society and the Smoke
Abatement League of Great Britain).



President : H. A. DES VOEUX, M.D.

Chairman : CHARLES GANDY.

Hon. Treasurer : Ald. WILL MELLAND, M.A., J.P.

Hon. Advisory Secretary : Sir LAWRENCE CHUBB.

General Secretary : ARNOLD MARSH, M.Sc. Tech., M.Inst.F.

Vice-Presidents :

H.R.H. THE PRINCESS LOUISE, DUCHESS OF ARGYLL.

THE RIGHT HON. THE EARL OF STAMFORD.

THE RT. REV. THE LORD BISHOP OF LONDON, P.C.,
K.C.V.O., D.D.

THE RIGHT HON. LORD NEWTON, P.C.

THE VERY REV. THE DEAN OF CANTERBURY.

Sir THOMAS BARLOW, BART., K.C.V.O., F.R.S.

Sir OLIVER LODGE, F.R.S., D.Sc.

Sir NAPIER SHAW, Sc.D., F.R.S.

Sir ERNEST SIMON.

PETER FYFE.

Alderman W. E. HINCKS, O.B.E., J.P.

Dr. J. JOHNSTONE JERVIS, M.D., D.P.H.

Coun. W. BROWNHILL SMITH, M.V.O., O.B.E., D.L.

AFFILIATED LOCAL AUTHORITIES.

Acton, Bath, Beckenham, Bethnal Green, Bingley, Birkenhead, Birmingham, Bolton, Bootle, Brighton, Bristol, Burnley, Bury, Buxton, Camberwell, Cardiff, Castleford, Chester, Chorley, Darlington, Doncaster, Ealing, Edmonton, Failsworth, Farnworth, Finsbury, Gateshead, Gloucester, Gravesend, Greenwich, Grimsby, Hackney, Halifax, Hammersmith, Harrogate, Hayes and Harlington, Heanor, Hereford, Heston and Isleworth, Holborn, Horwich, Hove, Huddersfield, Hull, Irlam, Keighley, Kensington, Kidderminster, Lambeth, Lancaster, Leeds, Leicester, Leyton, Lincoln, Liverpool, Manchester, Mansfield, Middleton, Mirfield, Mitcham, Newcastle-under-Lyme, Newcastle-upon-Tyne, Nottingham, Oldham, Poplar, Preston, Radcliffe, Richmond (Surrey), Rochdale, Rowley Regis, Royton, Salford, Scarborough, Sheffield, Rotherham and District Joint Committee, Shipley, Smethwick, Southall-Norwood, Southampton, Southend-on-Sea, Southwark, Stalybridge, Stepney, St. Helens, Stoke-upon-Trent, Stretford, Sunderland, Swinton and Pendlebury, Tottenham, Uxbridge, Wakefield, Wallasey, Walsall, Walthamstow, Warrington, Wednesbury, Wembley, Westminster, Weston-super-Mare, Widnes, Willesden, Wolverhampton, Wood Green, Wrexham.

Central Offices :

36 KING STREET,
MANCHESTER 2.

Office of Scottish Branch :

CITY CHAMBERS,
GLASGOW.

London Office :

71 ECCLESTON SQUARE
WESTMINSTER, S.W.1.

ANNUAL CONFERENCES OF THE NATIONAL SMOKE ABATEMENT SOCIETY.

1929	..	Buxton.
1930	..	Leicester.
1931	..	Liverpool.
1932	..	Newcastle-upon-Tyne.
1933	..	Sheffield.
1934	..	Glasgow.
1935	..	Bristol.

PROGRAMME



WEDNESDAY, October 14th—Industrial Day.

10-30 a.m. Opening of the Conference by Captain Harry Crookshank, M.P., Secretary for Mines.

11-15 a.m. CONFERENCE. FIRST SESSION.

Chairman : The President (H. A. Des Voeux, M.D.).

"A Review of Methods for the Prevention of Grit and Dust Emission, Especially from Pulverized Fuel Furnaces," by A. T. Barber, B.Sc., M.I.Mech.E. and T. F. Hurley, B.Sc., A.M.Inst.C.E., A.C.G.I. (of the Fuel Research Station).

Discussion.

1-0 p.m. Adjournment.

2-30 p.m. CONFERENCE. SECOND SESSION.

Chairman : R. Lessing, Ph.D., F.I.C., M.I.Mech.E., F.Inst.F.

"Modern Methods of Dealing with Smoke Prevention Problems in the Iron and Steel Industry," by H. C. Armstrong, M.Inst.C.E., F.Inst.F.

Discussion.

3-45 p.m. "The Problems of Smoke Emission in the Clay Industries," by E. Rowden, B.Sc., A.R.C.S., A.I.C. and A. T. Green, F.I.C. (Assistant Director of Research of the British Refractories Research Association).

Discussion.

5-0 p.m. (Approximately). Adjournment.

THURSDAY, October 15th—General Day.

10-30 a.m. CONFERENCE. THIRD SESSION.

Chairman : Sir Francis Fremantle, M.D., M.Ch., D.P.H., D.L., M.P.

"The Solution of the Domestic Smoke Problem,"
by Margaret Fishenden, D.Sc., F.Inst.P.

Discussion.

11-45 a.m. "Through a Glass Darkly," by Noel Carrington
(Member of Council, Design and Industries Assoc.)
Discussion.

1-0 p.m. Adjournment.

2-30 p.m. CONFERENCE. FOURTH SESSION.

Chairman : Sir Richard Gregory, Bart., F.R.S.

"The Effect of Atmospheric Pollution on Vegetation,"
by Sir Arthur Hill, K.C.M.G., Sc.D., D.Sc., F.R.S.
(Director of the Royal Botanic Gardens, Kew).

Discussion.

3-45 p.m. "Developments in the Investigation of Atmospheric
Pollution," by J. S. Owens, M.D., A.M.I.C.E.,
M.I.Mech.E.

Discussion.

5-0 p.m. (Approximately). Adjournment.

FRIDAY, October 16th—Health and Municipal Day.

10-30 a.m. CONFERENCE. FIFTH SESSION.

"Smoke, Light, and Health."

Chairman : Sir George Newman, G.B.E., K.C.B.,
M.D., LL.D.

"Atmospheric Pollution in Relation to Tuberculosis,"
by Sir Pendrill Varrier-Jones, M.A. (Cantab.),
F.R.C.P.(Lond.).

"Light and Clean Air in Relation to Surgical Tuberculosis,"
by Sir Henry Gauvain, M.A., M.D., M.Ch.
(Cantab.) F.R.C.S.

"The Obstruction of Light by Smoke and its Effect
on Health," by Sir Leonard Hill, M.B., F.R.S., LL.D.,
Hon. A.R.I.B.A.

Joint Discussion.

1-0 p.m. Adjournment.

2-30 p.m. CONFERENCE. SIXTH SESSION.

Chairman : Professor Sir John Robertson, C.M.G.,
O.B.E., M.D., B.Sc.

"Public Health Administration and Smoke Abatement," by A. S. M. Macgregor, M.D., D.P.H. (Camb.)
Medical Officer of Health, Glasgow.

"Smoke and the Sanitary Inspector," by Herbert
G. Clinch, F.S.I.A., Chief Sanitary Inspector, West
Ham C.B.

Joint Discussion.

5-0 p.m. (Approximately). CLOSE OF CONFERENCE.

SATURDAY, October 17th—

11 a.m. ANNUAL GENERAL MEETING

(For members and representatives of affiliated associations
and local authorities).

AGENDA.

1. President's Remarks.
2. To receive the Minutes of the previous meeting.
3. To receive the Annual Report.
4. To receive the Annual Statement of Accounts.
5. To elect—
 - (a) President.
 - (b) Vice-Presidents.
 - (c) Hon. Treasurer.
 - (d) Council.
 - (e) Executive Committee.
6. Any further business.

Please read this information carefully.

Conference Arrangements



Conference Fee.

A fee of 10/6 per member or delegate will be charged to defray some of the expenses incurred in arranging the conference and printing the *Proceedings*.

Meeting Place.

The opening ceremony, all sessions of the Conference, and the Annual General Meeting, will be held in the Lecture Theatre of the Science Museum, Exhibition Road, South Kensington.

As there is a possibility that on some occasions the seating capacity of the Theatre may be taxed, those attending the Conference are requested to fill in the attendance section on the Reply Form (green), indicating the sessions at which they will be present. An appropriate Admission Card will then be enclosed with the Advance Papers.

Papers.

Advance copies of the papers to be read, the Annual Report, list of Members and Delegates attending, and the Exhibition Handbook, will be forwarded a few days before the opening of the Conference to all from whom the green Reply Form has been received.

Date for Reply.

The arrangements will be greatly facilitated if all those attending the Conference will return the Reply Form as soon as possible, and in any case, *not later than Saturday, September 26th*.

Contributions to Discussions.

Members of the Conference will be asked to indicate, on a form (red) that will accompany the advance papers, in what discussions they wish to participate. This form should be completed and posted to the Secretary, The National Smoke Abatement Society, c/o the Science Museum, South Kensington, or handed to him *before* the opening of the Conference.

Resolutions.

Resolutions for submission to the Annual General Meeting may be sent in by members and representatives of affiliated associations and local authorities, but must be received *not later than Saturday, September 26th*.

Proceedings of the Conference.

The *Proceedings* to be published in December will contain all the papers and discussion in full. A copy will be sent to each member of the Conference, and further copies will be obtainable at 1/6 each, or in quantities at 12/6 per dozen.

The Exhibition.

The Exhibition, of which particulars are given in other communications, will be open during the usual hours of the Museum (Weekdays, 10 a.m. to 6 p.m. ; Sundays, 2-30 p.m. to 6 p.m.) and therefore can be inspected by members of the conference before the morning sessions, during the luncheon recess, or at the conclusion of each day's proceedings.

Literature.

Copies of the Society's publications, text-books, and other literature will be available at the Bookstand in the Exhibition Hall. Copies of the Exhibition Handbook and all publications of the Science Museum can be obtained at the Museum Bookstall near the main entrance.

Access and Facilities.

The Science Museum is in Exhibition Road, within five minutes walk of South Kensington Underground station. A subway from the station terminates less than 50 yards from the main entrance.

There are numerous hotels and boarding houses in the neighbourhood, and several cafes and restaurants near the underground station. Luncheons and teas are obtainable in the refreshment rooms of the Victoria and Albert Museum opposite the Science Museum. Buses to Exhibition Road, Nos. 9, 33, 46, 52, 73, 73A, 73B, 73C., *via* Kensington High Street or Knightsbridge ; Nos. 14, 30, 49, 74, 96, *via* Brompton Road or South Kensington Station.

Further Information.

Any further information concerning the Conference may be obtained from the Secretary, National Smoke Abatement Society, 36, King Street, Manchester, 2, or from October 1st also at the Smoke Abatement Exhibition, the Science Museum, South Kensington.

36 KING STREET,
MANCHESTER, 2.
Phone : BLAckfriars 0896.

ARNOLD MARSH,
General Secretary.

**NATIONAL
SMOKE ABATEMENT
SOCIETY**



**Proceedings
of the
Leeds Conference
1937**

**Price :
ONE SHILLING**

**Chandos House
Buckingham Gate
London, S.W.1.**

PROCEEDINGS

of the

NINTH ANNUAL CONFERENCE

of the

National Smoke Abatement Society

held at LEEDS

1st and 2nd October, 1937

CONTENTS.

Presidential Address, "IDEALISM," by Dr. H. A. Des Voeux	3
FIRST SESSION: TOWN PLANNING AND SMOKE ABATEMENT.	
Remarks by the Chairman, Professor R. Whytlaw Gray	9
Paper by J. E. Acfield	11
Paper by Charles Gandy	17
Discussion	25
SECOND SESSION: THE REGIONAL SMOKE ABATEMENT COMMITTEES.	
Remarks by the Chairman, Councillor G. H. Kitson	34
The Manchester and District Committee, by Dr. R. Veitch Clark	34
The Midlands Joint Advisory Council, by Dr. Matthew Burn	39
The Northumberland and Durham Committee, by Alderman David Adams, M.P.	42
The Sheffield, Rotherham, and District Committee, by Councillor W. A. Asbury	44
The West Lancashire and Cheshire Committee, by Dr. W. M. Frazer	48
The West Riding of Yorkshire Committee, by Dr. J. Johnstone Jervis	52
Discussion	56
THIRD SESSION: EDUCATION AND SMOKE ABATEMENT.	
Remarks by the Chairman, Professor J. W. Cobb	64
Report by the Secretary on behalf of the Executive Committee	65
Paper by Dr. F. A. Mason, Board of Education	70
Discussion	76
Publications of the Society	82

Friday Morning, 1st October: Annual Meeting.

PRESIDENTIAL ADDRESS.

“ IDEALISM.”

By H. A. DES VOEUX, M.D.

All nations, from the beginning of history, have had their ideals. Even among savage races principles of hygiene and prophylaxis are observed, which, though they may be wide of the mark when judged by modern scientific standards, are usually elaborate and certainly sincere. Where ghosts have been dreaded, not as gruesome phantoms, but as a real and present danger, men have taken precautions to prevent the return of their dead. These precautions generally involved extensive rites of purification. Sometimes the door by which the body was borne out of the house was sealed up, and the dead man was ferried across water to a distant place of burial by his relatives, who were afterwards required to bathe themselves and wash their garments before returning. It is not difficult to see in such rites a blind but not ineffectual attempt at disinfection. Those ancient races which attained high standards of civilization had their own codes of cleanliness, and the rules laid down by the early leaders of such peoples were by no means cursory. The Hindu Vedas*, for example, instructed the healthy man to rise an hour before sunrise, brush his teeth with a powder made from tobacco, salt or burnt betel-nut, using as a toothbrush a twig from some appropriate shrub. He was next expected to polish his tongue with a scraper made of gold, silver, copper or, if his economic position did not run to any of these, with a split twig ten fingers long. The mouth was then rinsed with cold water several times and the face washed. The eyes were treated with antimony and the nose with rape seed oil, which was believed to keep the mouth sweet, improve the voice and prevent the hair turning grey. He was also instructed to consult his looking-glass frequently, as this practice improved the complexion and prolonged life. He was required to take at least one bath a day, to anoint himself with oil, and to indulge in regular physical exercise. This regime of cleanliness and physical activity could not be outstripped in the English public schools of to-day—which, indeed, still lag behind the Hindus on a few points, such as the frequent use of the mirror.

The ancient Israelites were no less sticklers for cleanliness, as we may read in the book of Leviticus. Here we find not only precepts of personal hygiene, but edicts governing the cleanliness of the city as well. The priest was called upon not only to

* Ref. : “A History of Aryan Medical Science,” by Sir Bhaquat Sinh Ice.

diagnose leprosy in one of his flock and to act according to the law, but to deal also with leprosy in a house. What was meant by leprosy in a house it is hard to say; perhaps it meant a house in which a leper had dwelt, but the description suggests rather some sort of rot or fungus in the walls of the house itself. The passage runs :

“And he shall look upon the plague, and, behold, if the plague be in the walls of the house with hollow strakes, greenish or reddish, which in sight are lower than the wall;

Then the priest shall go out of the house to the door of the house, and shut up the house seven days;

And the priest shall come again the seventh day, and shall look, and behold if the plague be spread in the walls of the house;

Then the priest shall command that they take away the stones in which the plague is, and they shall cast them into an unclean place without the city.”

(Leviticus XIV, 37, 38, 39, 40.)

Cleanliness was an ideal with the ancient Greeks, as their open cities and their temples to Aesculapius, Hygeia and Panacea showed. The temples of Aesculapius, commonly situated on wooded hills or mountains near mineral springs, were nothing less than hospitals where the sick, attended by physician priests, were treated by bathing, massage and sleep.* The Romans, too, with their baths and aqueducts, were apostles of clean cities and citizens.

How was it then, that with these ancient ideals of cleanliness, personal and civic, before them, Europeans of the middle ages slipped into a disregard of hygiene so profound that we cannot remember the splendour and romance of those days without an ironic afterthought of filth, primitive sanitation and foul smells? The change from a love of cleanliness to its disregard is one of the strangest that man, in all his vagaries, has ever allowed. It was a change induced by apathy, not by a lack of idealism but by a passionate clash of ideals in which cleanliness failed to find acceptance upon the side of the angels.

To us, to-day, science and religion no longer seem at war. We seek trust as best we can in every field which lies open to us, nor feel that in doing so we are offering an affront to the things of the spirit. But in the middle ages the position was very different.

When Rome fell to the invaders in the fifth century the whole world was stunned. The foundation of power which had nourished a vast empire for generations was suddenly dried up. The subject nations had to get along as best they could, and they turned with

* Ref. : “History of Medicine”—F. N. Garrison.

confidence and faith to the great organization which could best support them at such a crisis—the Catholic Church.

The Church brought with it great spiritual gains—the Christian virtues of compassion for the weak and care of the sick. But it brought also its spiritual restrictions. Learning, at that time, was the province of the Church and her servants, and mediaeval thinkers were all under the ban of authority. Most of the learned entered the Church to find refuge from the turmoil of the outer world and opportunity for study. They were given their opportunity, but their studies were carefully delimited. For example, physical science and medicine were taught from abridged and much-translated versions of the ancient classical writers, and the use of any other books was forbidden. Nor was it permissible to attempt to establish facts of natural science by experiment. Truths were regarded as stationary, and the final judge in any controversy was the Church. It is a fact that at this time the works of Aristotle were taught in the schools of the west from a Latin translation of a Hebrew translation of an Arab commentary upon an Arab translation of a Syriac translation of the Greek text.* This attitude could not fail to paralyse any true advance in knowledge and the principles of public hygiene and cleanliness suffered, with other scientific principles, not merely an arrest but a reverse. Knowledge unless it is growing, begins inevitably to decay.

But in addition to this enchainment of learning, the Church brought with her a mystical ascetism, derived from the East, disdainful of carnal things. Mind and matter were separate entities. The spirit was eternal, the poor body but the dust which housed it, to be scorned and, as far as possible, ignored. It was this contempt for the body, and for the things of the world, which led to the strange divorce of cleanliness from godliness, and which, so Clifford Allbutt tells us, "in a few generations turned the cleanest people in the world into the most filthy."

Now, all this may seem to lie very far from the subject of smoke and smoke abatement, but in fact it is this old idea which has governed us since the fall of Rome, and governs us still to-day if we are to judge by practice. The fate of the body, for the mediaeval thinker was supremely unimportant. If man fared wretchedly here below, he would live blissfully hereafter; the ills and petty inconveniences of life on earth would be amply compensated in heaven.

He said and believed :

"Heaven is our heritage,
Earth but a player's stage."*

* Ref. : "Science and Mediæval Thought," by Clifford Allbut.

* "In Time of Pestilence," by Thomas Nash, 1567-1601,

There is nobility in the thought, but its practical results were deplorable. What use, men thought, to expend much labour upon a world in which they were but brief sojourners, born to trouble as the sparks fly upward. So the cities of the middle ages were magnificent fortresses, abominably drained and the roads were miry tracks where refuse was flung. Epidemics and plagues swept the country, and were regarded as visitations of God for sin. Even the Renaissance with its tremendous stimulus to learning could not shake ideas so deeply implanted in the hearts and habits of the people. Dirt and disorder were tolerated as necessary evils, and if smoke was not classed among the greatest of these it was simply because wood smoke is less offensive and harmful than coal smoke.

Coal was not used in England before 1239, when Henry III granted a licence to the city of Newcastle for the digging of coal; and it was not for centuries, of course, that the bulk of coal consumed became sufficient to pollute the atmosphere to the extent it does to-day. Yet even in those times smoky air gave offence, for we find Chaucer in the fourteenth century declaring roundly from the lips of the wife of Bath :

“ . . . smoke
And chiding wives, make men to flee
Out of their own house.”

Pride in clean cities was no outstanding virtue of Tudor times, even under glorious Elizabeth, as the old story of Sir Walter's cloak indicates. Shakespeare speaks of winter as a time when

“Blood is nipped and ways be foul”

as a matter of course. And again and again he reminds us how brief is our inheritance of this earth :

“We are such stuff
As dreams are made on, and our little life
Is rounded with a sleep.”

In the seventeenth century the quantities of smoke poured out over the city of London was sufficient at least to arouse the attention of the inhabitants, even apart from the volume contributed by the great fire. Indeed, smoke was seldom produced to better purpose than in that fiery destruction of old London, in whose rat-ridden, filthy houses the plague had run riot. Nor had there been any signal advance in providing clean streets. Splashes from passing traffic were so commonly expected that those with velvet or satin clothing to preserve walked on the inner side of the footpath near the wall. This is the origin of the custom by which the male escort takes the outer side of the pavement, to shield his woman companions from the mud. To

"take the wall," as it was called, was the prerogative of persons of quality; lesser fry made way. When two gentlemen of consequence encountered, of course a nice situation arose, in which the weaker finally went, not to the wall, but into the gutter, or even into the next world. Samuel Pepys tells how:

"Two men . . . jostling for the wall about the New Exchange, did kill one another, each thrusting the other through."

A sorry outcome of a lack of civic pride. John Gay, a century later, could still comment upon the difficulty of judging—

"When to assert the wall, and when resign."

In Pepy's day the air of London was not only polluted with smoke but rendered offensive by evil odours, some of which derived from the rotting limbs of traitors, impaled above Aldersgate. It is hard to understand how the citizens of London could tolerate such a practice, but not incredible when we remember that little more than a hundred years ago the bodies of law breakers were left dangling on the gibbets.

Contemporary of Pepys, that good citizen John Evelyn, staunch enemy of smoke, wrote hopefully of a London perfumed with the scent of flowering shrubs. In his diary he tells how he sat with the commissioners considering reforming the buildings and streets of London.

". . . and we ordered," he wrote, "the paving of the way from St. James's North, which was a quagmire, and also of the Haymarket about Piccadilly and agreed upon instructions to be printed and published for the better keeping of the streets clean."

Here was a begining of civic pride in cleanliness, and evidently not before it was sorely needed. Evelyn also tells, with great interest, how he saw Sir John Winter preparing coke, which he describes as—

". . . a project of charring sea-coal to burn out the sulphur and render it sweet. . . . What success it may have time will discover."

By the eighteenth century the foundations of modern scientific method had been well laid, but practice yet lagged behind discovery. Edinburgh housewives still cried "Gardylloo" as they emptied their slop-pales from the upper windows of tenement houses into the streets below.

The industrial nineteenth century did little to improve matters, rather the reverse; for though the paving and cleansing of streets became more common, the towns sucked in population from the country-side. Overcrowded slums added to the squalor of cities where the emissions of factory chimneys were blackening the air with soot and eating at the stone of ancient buildings. London

fogs acquired the reputation which they have never lost, and the regular pea-souper of Dickens' Christmas Carol can still be duplicated in our own time, now and then.

Can we, to-day, pretend that we have recovered the ancient Greek ideal of clean and open cities? Even now we tolerate in our midst the existence of slums whose vermin infested hovels are breeding grounds for disease. We are still content to live in cities which are periodically blotted out in fog, and permanently wasted by sulphur-bearing fumes. Content? If we are content with this we may as well be content to live in the pig-styes we deserve, and have done with it. Whatever our views on life and death it ill becomes us to leave our world to posterity in the same unkempt and grubby state in which we find it.

Would that the inhabitants of all our towns should become Idealists with regard to the buildings "within their walls" not only as to the architecture but as to preserving the structure from the destructive fumes emanating from fires and furnaces. If every citizen were an Idealist the City Fathers would have the authority and could exercise the power to clean the atmosphere, so as not to despoil the continuous gift which nature presents to us with no unstinting hand.

Friday Morning, 1st October: 1st Conference Session.

TOWN PLANNING AND SMOKE ABATEMENT.

**Opening Remarks by the Chairman, Professor R. Whytlaw
Grey, O.B.E., Ph.D.,**

on

SCIENTIFIC RESEARCH AND SMOKE ABATEMENT.

Research on the properties and behaviour of smoke is bound to influence our outlook on the wider problems connected with smoke abatement and atmospheric pollution. We know a good deal about the chemical character of smoke deposits, the proportion of tar, soluble and insoluble matter, sulphates, chlorides, etc., thanks to the researches of numerous workers and the activities of the Atmospheric Pollution Committee. Systematic observations are now made in many centres of the total suspended impurity in the air throughout the year and also of the sulphur dioxide present. It is, however, rather on the physical aspect of smoke pollution that knowledge is lacking, and I wish to direct the attention of this conference to two features of the suspended solid matter in the air which appear to me to be of significance. The first is the natural process of coagulation which is common to all smokes, and the second the range in size and relative numbers of the particles characteristic of smoke polluted air.

Apart from dust and grit the vast majority of smoke particles formed in combustion are initially very small, certainly of sub-microscopic dimensions, but they rapidly combine with each other and whether the pollution to which they give rise takes the form of large smuts or invisibly fine material depends on the degree of coagulation reached before the smoke escapes into the outer air.

In a dense smoke this process of coagulation takes place with great rapidity and if our chimneys were long enough the effluent would consist largely of gross aggregates or smuts and would contain relatively few of the fine floating particles which are so objectionable. Needless to say, this is purely an illustration and is not a practical suggestion.

When a smoke escapes from a chimney into the open air it is rapidly diluted and coagulation then takes place with extreme slowness for the probability of encounter of neighbouring particles is very small. The atmosphere hence becomes charged with myriads of fine particles which have not had time to flocculate or precipitate. It is these fine particles which are responsible for most of the evil effects associated with atmospheric pollution. They penetrate the respiratory passages and deposit in the lungs, they promote fog by acting as condensation nuclei for moisture,

they scatter and absorb sunlight and they adhere firmly to any surface they encounter producing the effects which are so evident in large cities such as Leeds. Large particles do not stick so firmly to surfaces and it is true to say that if the pollution in the air of our cities were in the form of particles of visible instead of microscopic and submicroscopic dimensions the evil effects would be much less evident. It is the particle of less than 0.5μ radius that are most numerous in city air and which are the most deleterious.

It is a matter then of some interest and importance to determine what proportion of the air-borne impurity is in the form of these fine particles. It is desirable, too, to know just what size ranges are the most objectionable.

Are the ultra-microscopic and amicroscopic particles of any significance? Or should attention be focussed only on those which can be resolved under the microscope? Until recently no methods were available for a complete survey of the number and size of the various grades of particle in smoke-polluted air.

During the last year we have been working at this problem in the Chemistry Department of the University of Leeds and we are now in a position to estimate approximately the various sizes of finely divided solid material contained in the air of this city. It appears that quite a large proportion of the total weight of impurity is in the form of large particles, varying from 1 to 10μ radius. Though these may form as much as 60% by weight of the total solid in the air their relative numbers are so small that their detection requires a few cubic feet of air to be used. Standard instruments, such as the Owens dust counter and the thermal precipitator, do not reveal their presence, because the volume of air sampled is too small.

These large particles consist of a variety of materials which can readily be identified under the microscope. Minute fragments of coal wholly or partially carbonized, coke, slaglike and glassy material, fused spheres as well as aggregations of much finer carbonaceous particles are common. Inside buildings it is these particles which settle out readily and form deposits of dust and dirt. They are, however, easily retained by filters such as are used in air conditioning plants.

Considering particles smaller than 1μ in radius we find that their numbers increase progressively with decreasing size. Very few observations have been made on the numbers in the range 0.3 to 1μ radius but the range from 0.3 to 0.1μ , that is down to about the limit of microscopic visibility, has been thoroughly explored. An average figure for this range for Leeds air is 2,000 particles per cubic centimetre. Though it is not contended that the most objectionable class lies wholly in the latter range there is no doubt that this group possesses all the harmful properties already mentioned. Probably the injurious character of polluted air

depends on the numbers of particles it contains round about this size range. Beyond the limits of microscopic resolution there is, however, a very numerous class of particle only detectable with the aid of the ultra-microscope. The lower limit of size is doubtful but may be given provisionally as 0.03μ radius. A normal figure for the number in Leeds air is 30,000 per c.c. To complete the catalogue another class of still smaller particles must be mentioned those which are too small to be visible in the ultramicroscope and which can only be detected by the Aitken counter or similar instruments. These, also, are about as numerous as the previous class. The total mass of the last two categories is very small and it is an open question whether their presence in air is harmful.

An examination, therefore, of the various sizes of particle in polluted air in Leeds reveals the presence of a class of large particle, few in number, but which forms a large proportion of the weight of the suspended impurity. It also shows the presence of a very numerous class of fine particle of sub-microscopic dimensions. Probably the most deleterious and objectionable class lies between these limits in the microscopic region and forms roughly about 50% by weight of the pollution.

What does emerge from these investigations is the wide range in size of the particles found in the air of cities such as Leeds and when further data have been collected the possibility of establishing a better criterion of harmful pollution than we have at present.

Paper by J. E. ACFIELD, Assoc.M.Inst.C.E., M.T.P.I.,

City Engineer and Surveyor, Leeds.

It was at the end of the last century that an appointment in Leeds caused me to remove from a town mainly residential in the South of England where the effect of coal consumption was so comparatively small that to the ordinary person it appeared to produce no ill effects. Within a day or two of arriving in Leeds, in the early days of November, a dense fog which persisted for a considerable number of days caused me to realize the difference there was in the atmospheric conditions of an industrial city—so much so that my Christmas Greetings were from “The Land of Fog.”

It is a great pleasure to say that since that time atmospheric conditions locally have improved enormously and, whilst some of it may be due to the closing down or slackening of certain industries, it is right to give credit to those who locally and nationally have taken their part in improving the conditions which arose from the emission of smoke. This has been chiefly due to the greater use which has been made of gas, electricity and coke for a variety

of purposes. One must feel, however, that the progress in even these matters is not always in a straight line and that the location of production of these several means of light and heat should be the subject of serious consideration.

It was stated in the middle of the last century that the gas works in the town of which I am a native were removed sufficiently far from the town to prevent any bad smells. The source of the bad smells, it should be noted, was not disclosed. At the same time I must confess that the frequent visits which I paid to those gas works in my younger days had a beneficial effect and the conditions surrounding gas works are much better than those of a quarter of a century ago. I remember again that on one occasion I was debating whether to become the tenant of a highly desirable residence, and that I was deterred from doing so by finding that roses would not grow in the garden due to the existence within a comparatively short distance of coke ovens. Coke ovens are now included among the Special Industries and come within the control of planning for that reason.

Again, even the most modern and best designed of the high-power electricity generating stations have not been free from criticism sometimes as regards their location and often for the emanations from their chimneys and from their coal pulverizing plant, all of which I think goes to show that there is room for the exercise of town planning powers in connection with the location of these works, which are so useful in securing smoke abatement, and I am pleased to say that I find some indication of advice being sought before commitments are made with regard to the acquisition of sites for carrying out these operations.

The Town Planning Act has for its object certain definite ends; to control development, to secure proper sanitary conditions, amenity and convenience, to preserve existing buildings or other objects of architectural, historic or artistic interest and places of natural interest or beauty and generally to protect existing amenities.

It does not usurp the functions of any other Act except the Town Planning Act of 1925, and Section 12 of the Crown Lands Act, 1927, and Sections 40 to 45 of the Local Government Act, 1929, which are now repealed.

Powers granted under the Public Health and other Acts remain in force including the Public Health (Smoke Abatement) Act, 1926, and if a further extension of powers is necessary with regard to any matters dealt with under those Acts it seems that they would be best secured by amendments to the appropriate Act.

I have received two copies of the admirable journal of your Society containing articles on "Smokeless Zones."

In the first of these, published in February 1936, under the

sub-heading "Ways and Means," there is a suggestion that Section 12 of the Town and Country Planning Act of 1932 provides a means of securing Smokeless Zones.

The second article, published in February, 1937, though partly in the same handwriting, makes no claim to any alleged powers contained in the Town and Country Planning Act but refers to "the legislation necessary," the inference being that powers are not possessed by local authorities and that they cannot be secured under existing legislation to secure Smokeless Zones.

I do not feel competent to express an opinion on such a point.

Referring to the suggestion made in February, 1936, that under Section 12 of the Town and Country Planning Act of 1932 a large City having town planing powers in its central area could secure the prevention of smoke emission in that area and that the power to secure control is under the Act applicable to existing buildings as well as new buildings, the essential words on which reliance was placed are no doubt that the scheme may include provision "for imposing restrictions upon the manner in which buildings may be used" and that they "may be made applicable with or without modifications to existing buildings."

Before going further I should make it clear that "the manner in which buildings may be used" is the form of words which authorizes the Town Planning Authority to regulate the class or classes of buildings which may be erected in certain areas without the prior consent of the Planning Authority, and also sets out what class of building may be allowed with consent of the Authority or may not be allowed at all. This form of regulation of planning is called zoning—and to name a few they are—Residential Zones, Business Zones, Industrial Zones, and so on.

Reverting to the claims made as to use of powers under Sections 12 and 13, it should be remembered that there is a further Section, No. 19, which specifies in sub-section (1) that in certain cases no compensation shall be payable with respect to the enforcement of restrictions made under these Sections, followed however in sub-section (2) by the proviso that this exclusion of compensation can only be inserted in a scheme provided it is also made clear that "existing buildings may be maintained and their existing use continued" and that if an existing building is demolished and a new building erected in its stead within 2 years of the said demolition the new building may be used as was the former (except it be a building used for a special industry, i.e., a noxious or offensive trade, and the zone in question is one from which special industries are excluded).

This, I understand, means in short that compensation is payable if the Authority interferes with the present user and it therefore follows that any action taken to vary the nature of the

user in any way will involve in each case the payment of compensation.

How many cases will there be in the central area of a great City where when a building is demolished there will not be another building in course of erection within two years?

Given the power, if available, of requiring an alteration in the type of fuel used which could be operated under any power by the Local Authority, what possibility is there of any action being taken with the onus of compensation in almost every case?

New Buildings in Leeds.

What is happening at the present time?

I can only speak for Leeds and here I find that in the case of 27 buildings of any magnitude erected since April 1st, 1930, in the central area, and of which I have the necessary information, the type of fuel used for central heating is in 18 cases coke, 3 coal, 5 oil and 1 gas, and in all cases where the fuel for cooking is known it is either gas, electricity or steam. If the Corporation had possessed powers to require the change, subject to compensation, it would probably have achieved very little more and might have been at considerable cost to do so.

It appears therefore that were there powers available under the Act of 1932 which could be brought to bear in the way suggested its operation would be expensive and it would achieve little.

This must not be construed to mean that there are powers under that Act which can be made applicable in the way suggested. In my view no authority would be given to embody such an interpretation of the Sections referred to in a scheme for such an area, and, moreover, such authority, I am sure, would not be asked for. I may add that no resolution to plan the central area in Leeds has been passed and that I know of no present intention of passing such a resolution.

In connection with zoning, there are always (1) the purposes for which a building may be erected and used without the consent of the Council, (2) the purposes for which buildings may be erected and used only with the Council's consent and (3) purposes for which buildings may not be erected and used.

In residential zones industrial buildings can only be erected and used with the Council's consent, and in Leeds in one case a special resolution imposing the use of smokeless fuel was passed in the case of an extension to a factory.

This may seem paradoxical to some of you who probably hold the view that the situation should be reversed and that the use of coal might more properly be approved in the case of a factory and that the consumption of coal in the houses should be restricted or forbidden. Still I console myself when I look at the competition award photographs reproduced on the covers of your journal.

The Corporation is carrying out a very large re-housing scheme and in one case where something like 10,000 houses will be erected, there is a proposal to zone an area adjoining for light industrial purposes in order to secure work for persons who will live on the estate and with a view to attracting light industries.

In order to secure, if possible, that the existence of this zone on the fringe of the Housing estate shall not be detrimental to the general well being of the estate and those who will live there, in these very special circumstances a clause has been inserted in the scheme which provides that the zoning shall be confined and defines a "light industrial building" as a building the use of which for the purposes of any trade, manufacture, or business shall not cause the emission of such smoke, fumes, dust, noise or odour, as will in the opinion of the Council be offensive, and the generation of power for which building shall be by electricity, coal-gas, smokeless fuel, or such other means as may be approved by the Council.

It will be realized, of course, that the scheme has a long way to travel and that at the present time the manner in which the Corporation will attain its object in this case is as yet uncertain.

Housing.

Coming to other matters of interest in Leeds regarding smoke abatement; as many of you are aware the Corporation of Leeds as long ago as 1926 experimented with the provision of houses with ranges or fireplaces capable of burning coke in living rooms. I am informed by the Housing Director that there are now 4,200 completed houses and cottage flats equipped with ranges specially designed for the burning of coke and that all houses now being erected on housing estates are so equipped. Coke is supplied to the tenants of these houses or any houses similarly provided with coke-burning ranges or fireplaces at the rate of 1/1 per bag containing approximately 84 lbs., the supply being limited to two bags per fire per week. The quantity supplied during the twelve months ending the 30th of June, 1937, was 85 tons.

There are always difficulties which follow in the train of progress and one of these is the possible deficiency in ventilation of habitable rooms as a result of the introduction of central heating, gas fires and electric radiators.

Where there is a fireplace for coal, coke or other smokeless fuel there is an adequate flue running vertically through the roof which should act as an efficient outlet ventilator, but if there is no flue then the maximum ventilation which can be required in Leeds, and, I believe, elsewhere, is the insertion of a perforated grating or terra cotta brick in the external wall which, if it operates, is not an efficient ventilator (whether inlet or outlet), and which in practice is frequently found to be prevented from operating at all.

In many cases the flues used in connection with gas fires are not effective for this purpose.

For this reason I believe there is a balance to the good as a result of the discontinuance of the fixing of gas fires in bedrooms on housing estates in Leeds. There is a potential ventilator in every bedroom with a fire place and in the event of illness there can be heat in the bedroom continuously, if necessary, which, if gas fires are used, is in many cases impossible owing to the comparatively large cost of continuously using a gas fire. I am informed that the cost may vary from .129d. to .181d. per hour per radiant.

The Leeds Civic Hall.

There is one other item of Leeds information which will probably be of interest. In the Civic Hall opened by King George V in 1933, which houses the Lord Mayor, the Council, and several of the larger departments, gas is used both for the purpose of heating the boilers for central heating and ventilation, for the domestic hot water and for cooking purposes.

The rooms and corridors which are heated have a cubic capacity of 1,834,668 feet and the superficial area of the rooms and corridors is 125,000 sq. ft.

The Manager and Engineer of the Gas Department informs me that the gas consumption for the central heating and hot water supply for the twelve months ended 31st March, 1937, was 19,929,400 cu. ft. and the total cost of the gas was £1,350 4s. 0d., giving an average price of 1/4.26d. per 1,000 cu. ft. or 3.46d. per therm. He has also supplied the following information:—

Town gas supplied by the Corporation gas works is used entirely as the primary fuel for these services, and the "Vesta" boilers used are unique, inasmuch as they embody a new process of consuming gas for water heating which enables gas to compete with either oil or solid fuel fired boilers for central heating, hot water supply, and steam raising.

This is made possible with "Vesta" boilers because their effective output is over 90% of the B.T.U.'s of the gas consumed in the case of central heating, and 85% in the case of steam raising, while all stand-by losses are conserved to do useful work.

The plant consists of—

Central Heating and Plenum Plant.

Three batteries of "Vesta" automatic gas fired boilers each having a maximum output of 2,300,000 B.T.U.'s per hour, which are used for dealing with approximately 20,000 sq. ft. of combined radiator and panel heating surface, together with Plenum air conditioning and heating plant, capable of handling 8—9,000 cu. ft. of air per minute.

Domestic Plant.

The whole of the domestic hot water is provided by a "Vesta" gas-fired steam boiler, capable of evaporating 900 lbs. of steam per hour at 100 lbs. pressure, the steam being conveyed to various parts of the building for the operation of calorifiers.

The whole of this plant is entirely automatic and represents the latest practice in central heating, steam and hot water supply equipment.

The heating of the building is carried out by three systems, i.e., radiator heating in the corridors and certain rooms, panel, floor, ceiling and wall heating for main entrance hall and reception rooms, and plenum heated air ventilating system circulating throughout principal portions of the building.

Radiator surface 15,700 sq. ft. = 2,360,000 B.T.U.'s per hour

Panel surface 4,500 sq. ft. = 550,000 B.T.U.'s per hour

Plenum system 8,500 cu. ft. per minute = 408,000 B.T.U.'s per hour

Total = 3,318,000 B.T.U.'s per hour

Hot water services from steam supply, maximum requirements = 1,200,000 B.T.U.'s per hour

The cooking is directly by gas or by steam generated by gas boilers.

Paper by CHARLES GANDY.

So every spirit, as it is most pure,
And hath in it the more of heavenly light,
So it the fairer bodie doth procure
To habit in, and it more fairely dight
With cheareful grace and amiable sight,
For of the soule the bodie form doth take :
For soule is forme, and doth the bodie make.

Spenser—Hymn in Honour of Beauty.

Why is it that in this country, which abounds in beautiful natural landscapes and has been endowed with so many wonderful examples of fine architecture both historical and recent, there is hardly a city which, taken as a whole, can be described as beautiful? The answer is two-fold and, as beauty is a matter both of form and of light or colour, so ugliness in modern cities is due partly to uncontrolled, often very rapid and quite unconsidered development, but perhaps even more to the dirtiness of their buildings and their sun-starved atmosphere. Town planning and smoke abatement are both needed, and the purpose of this paper is to consider how the one may assist the other.

I have referred to the ugliness of cities rather than to other faults with which town planning is concerned because, like that of the architect, the art of the town planner has to deal not only with function but with form. He will be judged by the appearance of the cities he helps to create. The growing public interest in town planning may be largely inspired by the fact that present thoroughfares in and around a city are not suited to the needs of modern traffic, but it is also due to a revulsion from the individualism which allowed any speculative builder or manufacturer acquiring a site in any part of the city to destroy the amenities of a whole neighbourhood. It is a common observation that nature seems to create beauty by accident. The same is not true of a city, or indeed of any human handiwork. The beauty of a cathedral does not result from any accidental grouping of materials, but partly from the design of its original architect and partly from the efforts of succeeding generations to ensure that extensions and repairs shall be in harmony with the existing fabric. It also depends on its natural setting, and on those grass lawns and trees which are so necessary to show to advantage many types of architecture. Unfortunately, in regard to most of our cities, there has been neither an original design nor any real effort, particularly in the past century or more, when the growth of cities has been most rapid, to ensure their harmonious development. Their natural setting has been disregarded, plant life will not flourish in them, and even their business men until recently tended to regard them as mere workshops for the building up of private fortunes and, when they could afford it, sought the amenities of life for themselves and their families by living well away from the smoke and dirt for which they were responsible. We have begun to realize that such amenities should be the common heritage of all the inhabitants of a great city, and are spending much public money, not only on housing, but in the erection of fine public buildings. It is unfortunate, however, that no sooner have we succeeded in lighting a lamp of architecture than we proceed to smother it under bushels of soot. As a speaker at this year's meeting of the British Association put it, we have not yet outgrown "the childish habit of fouling our own nest."

Unlike the architect, the town planner has to deal with property which does not belong to those for whom he works, but to a very large number of individual property owners, each of whom is inclined to be more interested in the value of his particular property and his supposed right to use it just as he pleases than in the development or well-being of the city as a whole. This means that the town planner cannot work without the help of legislation, often more or less strenuously opposed. No town planning scheme can be successful unless the Local

Authority responsible for it has previously obtained from Parliament the right to interfere more or less with the freedom of the private owner, and to differentiate for that purpose between owners in one part of its area and owners in another part. Whether we as owners or occupiers of particular properties may like it or not, this control and differentiation has come to stay and is likely to increase as time goes on. It must, in fact, increase if our cities are to be pleasant and attractive places to live or work in, and if the surrounding country is to be protected from disorderly building developments.

The Town Planner and Smoke.

So far the smoke problem has not, I think, been an immediate concern of the town planner. He has, of course, had it in mind incidentally, and perhaps subconsciously, when zoning parts of a city area for residential purposes, or for light or heavy industries, and perhaps also in his recommendations for a green belt round large cities, and in the siting of satellite towns as far removed as possible from the smoke area. Surely the time has come when he should consider the smoke problem as an *integral* part of the task with which he is faced. He should constantly seek to visualize the city as it might have been if smoke had been unknown—that dingy slum street, or office block, as they might have been if their brick or stonework had suffered nothing worse than natural weathering—and he must remember that the city of the future, for which he is planning, will in fact be a smokeless city. He should, therefore, consider carefully whether the restrictions upon the freedom of individual owners, with which he is familiar in other matters, may not also be applied in bringing the age of the smokeless city much nearer than it at present seems to be. To do this effectively further legislation may be needed. I shall confine the remainder of this paper to a suggestion recently put forward, viz., that an Act should be passed enabling Local Authorities to incorporate in town planning schemes, or make byelaws, imposing a restriction on smoke emission applicable to all buildings in certain specified areas or zones. In doing so I shall borrow from a joint paper prepared by Miss FitzGerald, Mr. Marsh and myself, and read at a meeting of the Royal Institute of British Architects.

Even apart from town planning schemes, there is really nothing unfamiliar to us in restrictions on the use of buildings in private ownership. Such restrictions abound in the Public Health and Factory Acts, and are also commonly found in title deeds. When first imposed they are frequently resented, but once they have become familiar we no longer notice them. In some cities abroad owners are compelled by law to clean the entire exterior of their buildings every eight or ten years, and though

involving considerable expense this is done as a matter of course. The restriction now suggested would not involve expenditure, except in some cases a small initial outlay, comparable to that required when water sanitation was made compulsory.

The present restrictions on smoke emission are practically confined to factory smoke, and if properly applied by the authorities concerned would go far towards minimizing smoke from that source. It is the smoke from non-industrial sources which is the most difficult and most complex aspect of our problem. As stated in the recent Report of the Chief Inspector on Alkali, etc., Works, "the time will probably come when the burning of raw coal will not only be regarded as an offence against public amenities, but will be prohibited on economic grounds, but that cannot be until a much greater and cheaper supply of fuel or energy is available." No general prohibition of smoke from the domestic fire is of course possible, or in present conditions desirable. Must we then as a society be content to wait for the gradual voluntary adoption of smokeless substitutes, and for the manufacture of such substitutes in sufficient quantity to meet all requirements, helping only where we can by educational propaganda? In fighting a recognized evil there is a point at which the public are sufficiently educated to wish that more positive action should be taken. For many reasons it is now generally recognized that the problem of smoke is an increasingly urgent one, not only from the point of view of health, but to save from degradation the many great housing estates and important new buildings recently erected, as well as to check the tendency of those with motor cars and other easy methods of transport to abandon the city area and encroach more and more on the countryside, in an effort to place their homes in natural surroundings not already spoilt by smoke. People are beginning to look to this Society for a more definite lead in smoke abatement. Such a lead cannot be given without careful consideration, but as a beginning the suggestion referred to for the control of smoke emission in specified areas does seem to deserve such consideration. Clearly, we should not, as a society, advocate regulations which would be felt by the general public to be arbitrary, or to affect too wide an area, or which might suggest unnecessary interference with private arrangements. I think, therefore, that any legislation for the control of non-industrial smoke should be of a kind that could be applied locally and after full consideration of the circumstances affecting the area to be controlled. On the other hand, we must not be deterred by the fact that some opposition to our proposals is likely to be met with, whether the opposition be that of individuals, or of vested interests. If the proposals themselves are such as to secure a sufficient backing by the general public, opposition should

be welcomed. It will help to draw further attention to the evil for which we are seeking a remedy, and may also result in helpful criticism.

Byelaws Required.

Shortly stated the suggestion is that Local Authorities should be empowered by Act of Parliament to make byelaws or schemes under which the emission of smoke would be declared a statutory offence only in certain areas or zones selected for that purpose by the town planning authority concerned. The Act could be passed as an addition either to public health legislation, or to town planning legislation. In the former case it would, of course, be read with the existing Public Health Acts and particularly with the provisions of Ss. 101 to 106 of the Public Health Act 1936 relating to smoke nuisances. For practical purposes it would be convenient to provide that the emission of smoke in the area or zone to be controlled should be deemed a smoke nuisance within the meaning of the sections referred to. It would then follow that the same could be dealt with on the lines now familiar in dealing with industrial smoke—i.e., by a notification to the owner or occupier of the premises, an abatement notice, and if necessary by proceedings. In any such proceedings the mere emission of smoke would constitute the offence, but it would still be possible for the offender to prove that the best practical means for preventing it had been used, having regard to cost and to local conditions and circumstances. This is probably necessary, as the areas under consideration might include, e.g., new buildings where heating plant equipped with mechanical stokers using finely divided raw coal would on occasion emit small quantities of smoke, although generally inoffensive, and to change such installations would be a matter of great expense. In considering whether the best practicable means had been adopted the Court would have regard not only to the apparatus installed, but also to the manner in which such installation is used. It might also be desirable to exempt from control low rented cottage properties, if any, in the zone affected.

Support for the Proposal.

The proposal for such smokeless zones has already received considerable support. It was, for instance, referred to in a leading article in the "Manchester Guardian" (Oct. 27th, 1936) as "a scheme which is both reasonable and hopeful as a first step towards controlling the non-industrial parts of a town," the article concluding with the opinion that "as a beginning smokeless zones (which can easily be incorporated in town-planning schemes) would be the best object-lesson a town could have." I have myself discussed the suggestion with many occupiers of

premises in the central area of Manchester, and gather that the experiment if made in that area would be generally well received.

An alternative suggestion was put forward by the late Commissioner for Special Areas, Sir Malcolm Stewart, in his Report presented to Parliament on 27th October, 1936, "Increasing pressure," he said, "is being brought to bear upon manufacturers to reduce smoke emission, and plant has often to be installed which involves a considerable capital outlay. Is there not a case in the interests of the public for insisting on a similar abatement of smoke from open hearths which causes so much damage and is deleterious to health? I recommend that a start should be made by insisting that all houses over an agreed rateable value should not use in open hearths anything except Welsh or other smokeless fuel." This suggestion is open to the criticism made in our joint paper in regard to the difficulty of making and enforcing byelaws (under Section 5 of the Public Health (Smoke Abatement) Act, 1926) requiring the provision in new buildings of arrangements for heating or cooking calculated to prevent or reduce the emission of smoke, viz., the difficulty of discriminating between existing buildings and new buildings, or between buildings of different rateable values, because of the impossibility of adequate supervision by the inspectors responsible for bringing offenders before the Court. We then concluded that any attempt to legislate in regard to the "indoor" arrangements of buildings privately occupied would result in failure, and that in regard to such buildings the only matter really concerning the public and to which smoke abatement legislation should be directed is the actual emission of smoke "outdoors into the surrounding atmosphere." If we can begin by securing that the area within which such smoke emission is to be prohibited shall be closely defined, the difficulty of enforcing control by adequate supervision will be minimized.

Suitability of Central Areas.

It would be for the Town Planning Authority concerned to select the areas best suited for scheduling as smokeless zones. In many cities the central area would no doubt be selected, though the same principle could be applied elsewhere, e.g., in the vicinity of hospitals, parks or aerodromes, important architectural monuments or even to some housing estates. Some reasons for selecting central areas may be stated as follows:—

- (1) The majority of premises in such areas, i.e., large modern block of offices and commercial premises, are already equipped with smokeless apparatus. These, while contributing no smoke to the area themselves, are adversely affected by their more careless neighbours,

- (2) The smoke emission from a city building where old fashioned coal fires are still used is very heavy, smoke often being emitted from every chimney and coming from a score or more of separate offices, as will be noticed by anyone who troubles to look at chimney stacks in the city on a winter morning. A private house usually has not more than one or two fires burning.
- (3) To occupy for business purposes the central area of a city is in itself a privilege and has accompanying responsibilities.
- (4) In making restrictions which may involve owners or occupiers in additional expenses it is advisable to begin with those who can best afford it. The cost of conversion to smokeless methods would generally be very small compared with the rent and rates paid for city premises. In such an area there would not be many of the older type of houses occupied by working class people and these could, if necessary, be exempted. In any case, such houses are tending to disappear under Slum Clearance Schemes. Modern blocks of flats, if any in such areas, can and should be smokeless.
- (5) Central areas are densely populated during daylight hours. A careful estimate was made for the Manchester Corporation of the number of persons who daily come into the city from districts outside the city boundaries and it was calculated that as against a night population for the whole city of 744,000, the day population was over 1,000,000. In addition to the quarter of a million persons coming from outside there are many thousands who come each day from other parts of the city into the central areas, so that a very large proportion of the population for a large part of each year enjoy only such daylight as can reach the centre of the city—nearly one half being now shut off by smoke. In Leeds, where the population is about 458,000 it may be estimated that between 150,000 and 200,000 persons come daily for work or shopping into the central area.
- (6) The supply of smokeless fuels is at present inadequate for a general substitution of those fuels, and the substitution must be progressive. In starting with the central areas it will be found possible to extend similar regulations to adjoining areas as and when more ample supplies of smokeless fuels are available. Further, as the benefit of such a smokeless zone or area comes to be realized it is likely that the area will be voluntarily extended.
- (7) There is no reason to anticipate difficulty in the case of hotels or clubs. Cooking in such places is mostly done by gas or electricity. The rooms will be warmed by central

heating. There is already sufficient good solid smokeless fuel on the market to supply open fires used for cheerfulness in public rooms.

- (8) The adoption of smokeless methods by its leading citizens and the possibility of being able to walk through an area without seeing a single smoking chimney would be of the greatest value as an example to others in the city.
- (9) The immediate result of the suggested regulations (of which due warning would of course be given) would be that those whose business it is to provide smokeless substitutes would compete with one another to meet the wishes of their new customers and to provide the most generally satisfactory substitute. This would be a useful stimulus to industry and employment.
- (10) Any scheme for the replanning of a central area should include the placing near the city centre of one or more parks or public gardens, and this cannot be done successfully if there is a heavy sootfall from adjoining buildings.
- (11) Last, but by no means least, the scheme would attract very great public attention and discussion.

It is hoped that detailed criticism of this suggested new line of attack on non-industrial smoke will be made at the present Conference. Meanwhile, some of the objections which must naturally occur should perhaps be dealt with in this paper.

Possible Objections.

Probably the most important is that the prevention of smoke emission in a limited area will not prevent that area being polluted. We constantly have to insist that smoke knows no bounds and should be controlled on a regional basis. It should however be remembered that smoke is of two kinds, the lighter smoke which usually comes from factory chimneys, and the heavier smoke which comes from the domestic or office fireplace and tends to settle especially in calm weather somewhere near its source of emission. Anyone familiar with town life knows how smuts descend from nearby chimneys. It is such heavier smoke which chiefly accounts for the blackening of buildings and the destruction of stonework and which is responsible for the more or less constant rain of smuts and a great amount of the dirt contained in local fog. Again, people say that it is of little value to get rid of visible smoke if you substitute for it the invisible fumes from coke or gas fires. This objection is a mistaken one, for the vapour and gases from such fires are quickly dispersed by diffusion or dissolved and precipitated in the natural humidity of the atmosphere.

Another important objection may be that the proposal "savours of compulsion." The Society's work hitherto has been mainly educative, and we should not antagonize support by suggesting interference with individual liberty. It may also be regarded as unfair to differentiate between buildings within a specified area and those outside it. Against these objections it may be pointed out that some interference with liberty, and also the differentiation complained of, are a necessary part of all town planning. People naturally wish to be free to have the fires they like best in their homes and offices, but should remember that the fuel they put on such fires does not remain where it is put. The proposed control dealing only with smoke omission does not interfere with such freedom. We cannot object to people making smoke within their own premises, if they like it, but when such smoke comes outside into the open air, which is the common and most valuable property of all citizens, it is fair that they should be penalised. The enjoyment of unpolluted air and light is itself a fundamental liberty which those in authority should do all in their power to protect. If the proposals made in this paper deserve support, it is because they may assist in protecting that liberty.

A rough suggestion for a Bill to give effect to the proposal is appended.

Public Health (Smoke Abatement) Act, 193—.

1. (a) A local authority may make byelaws prohibiting the emission of smoke from buildings in any area within their district specified in such byelaws.
- (b) The emission of smoke from any building in contravention of byelaws made under this section shall be deemed a statutory nuisance and a smoke nuisance within the meaning of Part III of the Public Health Act, 1936.
- (c) Byelaws made under this section may provide that any building or part of a building occupied only as a private house shall while so occupied be exempt from the operation of such byelaws.
2. This Act may be cited as the Public Health (Smoke Abatement) Act, 193— and shall be construed as one with the Public Health Act, 1936, etc.

DISCUSSION.

Mr. George W. Farquharson (Birmingham) said that Mr. Acfield had stated definitely that the Town and Country Planning Act, 1932, did not usurp any of the powers and legal obligations of the Local Authorities as laid down in the Public Health Act, 1875, and the Public Health (Smoke Abatement) Act, 1926, which to-day, the 1st October, came into operation within the Public Health Act, 1936, and any scheme for creating a smokeless

zone in the centre of large cities under the Town Planning Act, 1932, would apparently result in the payment of compensation, although Section 70 of this Act did give the Minister of Health power to state whether compensation should be excluded from any zoning scheme. He did not think that any Local Authority would go to that extreme, especially when they had the powers to deal with a smoke nuisance under the present Public Health Act.

For future zoning of industrial areas he thought the Town Planning Authority should, when plans were submitted, make a proviso asking for the complete combustion of any fuel on any installation used within the factories. This would cover not only their boiler and furnace plants, but also the heating arrangements and incinerators, etc.

In relation to the domestic ranges burning coke, he would like to ask Mr. Acfield the following questions: (1) What material was used for the hot water boiler—copper or iron? (2) Had his department any objection to the use of copper boilers and coke fires? (3) Had his department any experience with the new aluminium alloy cast boilers which cost the same as copper, but were not subjected to the pitting and corrosion which were experienced with copper and coke? And, finally, would he recommend the use of coke in the case of four-storey tenement flats which Local Authorities of large cities were now erecting for rehousing purposes?

He thought Mr. Gandy's Utopian idea was worthy of every consideration, but he struck at the root of the evil in the statement that the present restrictions on smoke emission were practically confined to factory smoke, and if properly applied by the authorities concerned would go far towards minimizing smoke from that source. Did he think that further legislation would encourage local authorities to carry out their obligations?

He stated that no general prohibition of domestic smoke was possible or desirable. So that considering a central zone, i.e., a business zone, it left us with such buildings as offices, shops, banks, hotels. He agreed with him that such buildings could be a source of heavy pollution. We all knew the type of old Victorian town-house, the rooms of which had been converted into separate offices of all descriptions. For want of a better name they could be called "Houses-let-in-Offices." In many cases the Victorian grate still remained in every room, and during the winter as many as 10 to 20 coal fires contributed their share of pollution from the one building. So that in the central zones the smoke pollution expected was from (a) open fire grates, (b) heating and cooking arrangements, and (c) trade refuse burning whether in incinerators or the open yards at the rear of the premises. Surely it was not necessary for further legislation to control smoke from these sources. Local authorities already had the necessary powers, i.e., Section 101, Public Health Act, 1936:—"Any chimney (not being the chimney of a private house) emitting smoke in such quantity as to be a nuisance, shall be a statutory nuisance under the Act. Section 343 defined "house." It said, "House" meant a dwelling house, whether private or not. Also, a "Workplace" was defined as not to include a factory or workshop (as according to the Factory Acts), but

included any place in which persons were employed otherwise than in domestic service. Therefore, it was his contention that office chimneys, etc., came within this section, 101 para. (b). Trade refuse burning in the open was covered by Section 92 para. (c). Any accumulation or deposit which was prejudicial to health or a nuisance, and for future buildings, Section 104 para. 2 gave powers for local authorities to make byelaws requiring the provision in new buildings (other than private dwelling houses) of such arrangements for heating and cooking as were calculated to prevent or reduce the emission of smoke.

Also, we had powers in Section 106 to deal partly by representation to the appropriate Minister with smoke nuisances from Crown premises, i.e., Post Offices, Ministry buildings, etc.

And, finally, Section 61 of the 1936 Act gave local authorities powers to make byelaws relating to the height of chimneys.

With all this legislation surely it was not necessary for further legislation. The duty rested with the local authorities, and every local authority should strive to make all their area a smokeless zone, not the central part. He noticed no mention was made of railway smoke in the central areas. What did Mr. Gandy propose to do about that? Here was a source of pollution which called for immediate consideration and in his opinion should be tackled first.

Mr. Thomas H. Ashford (Glasgow) said he thought it was unfortunate that local authorities permitted the unsuitable location of large-scale operations in their areas such as various metallurgical processes, foundries, coke oven plants, and even communal activities such as destructor plants. These were often placed in available sites either in the centre of or adjacent to closely populated areas and even close to residential areas, the result being that the officials in control of smoke abatement and sanitary work were inundated with complaints over an extended area. The emanations from these plants which were the subject of the complaints were in very many cases "characteristic" of the process, were quite consistent with the best practical means being employed in the process, and were not readily subject to remedial measures being taken. In consequence there was much discontent and criticism of the efficiency of the officials' efforts, the improvement, if any, that might be effected not being sufficient to appease the irate complainers.

Again, the location, arrangement and height of chimneys connected with small-scale operations, which caused an immediate and local nuisance, were not kept fully in mind by the responsible local departments. The initial mistake was made by the controlling authority who perhaps had a main eye on the architectural or æsthetic outlook rather than on the ultimate process results to be experienced. It would seem that in many instances there was an apparent lack of collaboration between the various departments concerned. In cases such as these, the often prohibitive cost of alteration and improvement prevented adequate solutions being found and led to much time and trouble being spent on complaints which should

never have arisen had the plants been subject to initial control so far as location and lay-out were concerned.

Conversely, the erection of housing schemes closely adjacent to concentrations of industrial activities of long standing, for example, foundries, railway running sheds, paper mills, chemical works, tar distilling plants, etc., was to be deplored, for very soon complaints begin and the conditions experienced by the harassed official are similar to those first mentioned. Individual tenants and associations of tenants volubly insisted "that the works be removed and complain that they should never have been asked to remove to such surroundings."

Foresight, common sense, and collaboration would go a very long way in town planning so far as smoke abatement was concerned to ensure that reasonable amenities were obtained and preserved.

Mr. H. E. Bloor (Inst. Gas Engineers) said in the first place he would like to say that he represented the Institution of Gas Engineers, and in his official capacity as a Director, Engineer, etc., of the York Gas Company he had taken a great interest in the activities of the Smoke Abatement Society for many years and was sorry to feel that the movement had made so little impression on the public conscience.

He could not refrain from telling them an incident which had occurred on his way to the Hall, and which was highly amusing having regard to the remarks of Dr. Des Voeux at the Lord Mayor's Reception.

He had fortunately turned his car into the street in which the Hall was situated, and then asked a postman for the Philosophical Hall. His reply was—"There it is; that black building on the left-hand side." Sometimes, said Mr. Bloor, one saw something which illuminated a subject, and he had brought with him a photograph which he thought the Secretary might like to have in his possession, showing the roofs of the Annex to the "Wells House Hotel," at Ilkley. On one side stretched away the moors, so that the wind from that side was pure, but the other side brought the smoke from the town of Ilkley. The photograph showed that the tiled roofs were perfectly clean on one side and black on the other, which he thought a very striking illustration of the effect of smoke.

Turning to the papers, Mr. Bloor wished to refer to two points in Mr. Gandy's paper, one where he said that "No general prohibition of smoke from the domestic fire is of course possible, or in present conditions desirable." He assumed that the meaning of that was that for economic reasons it was impossible to prohibit what was generally regarded as the cheapest method of continuous heating. It seemed to him that whilst this was true in the past, it could within a very reasonable period, say 10 years, cease to apply.

One speaker had said that there was already an ample supply of smokeless fuel available, but as one engaged in the manufacture of smokeless fuel, he could hardly agree with that. He would certainly agree if it were desired to abolish the use of raw coal in the domestic grate. In the ensuing 10 years, it would be possible to supply alternative means on economic terms.

On page 22, Mr. Gandy quoted Sir Malcolm Stewart who said—"I recommend that a start should be made by insisting that all houses over an agreed rateable value should not use in open hearths anything except Welsh or other smokeless fuel."

This again raised the question of economics and supply.

He would like to refer to the references to the installation of coke grates in building schemes and felt sure they would be surprised to learn that his company, as suppliers of smokeless fuel, had made what the directors thought a most generous contribution to the solution of the smoke abatement problem, in offering to provide, entirely at the expense of the Gas Company, the gas lighting equipment and the special grate required to enable the Corporation's standard grate for their housing schemes to burn coke. This offer, which would have cost the Corporation of York nothing whatever, and have provided their tenants with a highly economical and convenient equipment, was rejected in a very unceremonious manner, which clearly proved what had been stated by many speakers, that the first necessity was to educate politicians and municipal administrators, on the question of smoke abatement.

He felt that their efforts had lacked a definite point, and that the suggestion made by one speaker that they should frame a standard set of byelaws for adoption by municipalities should be adopted. It would be a great help in their propaganda as, in place of general propaganda against smoky atmospheres, the fight would be transferred to the definite question of adoption, or otherwise, of the proposed byelaws.

On behalf of the Institution of Gas Engineers he wished to thank the Society for giving him the opportunity of being present at the conference.

Councillor James Griffiths, J.P. (Chairman, Cardiff Health Committee), extended on behalf of the Lord Mayor Elect of Cardiff, Ald. Purnell, J.P., a hearty welcome to the members of the Smoke Abatement Conference, on their visit to Cardiff next year.

Councillor Griffiths described Cardiff as one of the cleanest and most smokeless cities in the British Isles, situated though it was in an industrial area which included one of the greatest steelworks in the country. The atmospheric gauge showed hardly any atmospheric pollution, a fact which he attributed to the use of Welsh smokeless coal, and to the scientific machinery introduced into the works for the purpose of smoke consumption.

He then stressed the contrast between the beautiful clean city of Cardiff and the smoke, grit and blackness of the industrial centres of England. He went on to state that the burning of raw coal not only caused pollution of the atmosphere, but also a loss of millions of pounds, owing to the fact that valuable by-products were being allowed to escape into the air. It was well that a conference of this description should be held in different parts of the country, in order to educate public opinion.

He urged that the administrators of local government should make

the greatest use of the powers they already possessed to abolish smoke pollution, and should press their Members of Parliament to bring to the notice of the Government the need for new and more stringent legislation for the abolition of the smoke-screen at present obscuring much of the beauty of our country, and help to bring health and happiness to our people by removing many of the evils which arose from a polluted atmosphere.

Councillor W. T. Lancashire (West Lancashire and Cheshire Regional Smoke Abatement Committee) congratulated Dr. Des Voeux on a splendid introduction to the Conference.

He said they could not be satisfied until the members of local authorities were smoke conscious. There was yet no attempt to deal with smoke for the future, as in the satellite towns such as that at Speke, near Liverpool. Five thousand houses were being built on agricultural land lying to the east of the air-port, and would be finished in five to ten years. When the wind was in the west smoke from the factories at Garston blew right across the air-port, and if nothing was done they would soon get smoke from the east as well. In these houses were being installed a coal range and coal fires in the bedrooms, in spite of the Liverpool Gas Company guaranteeing to supply the 5,000 houses with a complete supply of coke, and instead of the present range, to supply one of equal efficiency, and adapted to burn coke, at a price of 30/-less. This was rejected by the City Council.

The smoke from this new town would therefore be a menace to the air-port and to the health of the future children.

Councillor C. E. Keene (Leicester) said that in all cities there should be special inspectors with definite qualifications to devote their whole time to the smoke nuisance. He suggested that the Society should formulate bye-laws on the lines suggested by Mr. Gandy for placing before Parliament or the Ministry of Health. The Society should also use every means in its power to press the gas and electricity undertakings to reduce their prices to the very lowest in order to encourage the working classes to put these in their homes and so eliminate the use of raw coal.

Mr. I. Priestley (Chief Sanitary Inspector, Manchester) said that Mr. Gandy had put forward eleven good reasons why local authorities should prescribe within their districts certain central areas which should be scheduled as smokeless zones.

Another good reason might also be advanced, viz.:—that the substitution of central heating, gas or electric heating in place of the coal fire grate would considerably reduce the danger from fire in the buildings in such areas.

He had consulted one of the principal officers in a large city fire brigade and he assured him that such a scheme as Mr. Gandy suggested would be welcomed by fire brigade officers on that account.

The scheme propounded by Mr. Gandy merited very serious consideration,

If it could be accepted as a practical proposition, it should receive the full support of every advocate of atmospheric purity.

They must be satisfied however as to its practicability. He had heard the view put forward that sufficient smokeless fuel was not available to permit of this scheme being put into operation and he should like to hear Mr. Gandy's views on that point.

It might be that in some cases a slightly increased cost would fall upon occupiers in those areas, though in other cases, i.e. where the fire grates in a building were numerous, a system of central heating would probably prove less costly.

It was gratifying to know that the transition which Mr. Gandy was advocating was gradually but very slowly taking place. He could give numerous instances but would quote one. The offices in the Manchester Royal Exchange were originally heated by coal fires. In the building were 125 chimneys, so one could imagine the volume of smoke poured into the atmosphere during the winter months.

When the building was reconstructed a few years ago central heating was installed with the result that these coal fires were abolished. The reconstruction provided for a number of additional rooms which, if they had been heated by the old-fashioned coal grate, would have brought the number up to approximately 300.

If schemes of that character became more generally adopted, the smoke problem in the centres of our large cities and towns would be considerably simplified with economical advantage.

He came across a rather interesting publication recently which had been issued by the French Government. It was a list of the hotels in France. He did not suggest it was complete, but it did give very detailed information with regard to upwards of 6,000 hotels. In Paris alone particulars were given regarding 395 hotels ranging in size from 10 rooms to 600 rooms. It was worthy of note that 346 of these hotels (approximately 88 per cent.) were centrally heated. In the rest of France particulars of 5,949 hotels are given, of which 4,411 were centrally heated (approximately 75 per cent.). He was not aware that statistics of this character had been published with regard to hotels in this country, but he would venture to say that a far less proportion are centrally heated than those figures he had given.

He did not believe that the people in France were any more smoke conscious than we were in this country, *but they had realized how economies could be effected and had taken advantage of that knowledge.*

At that Conference, as in previous Conferences, much stress was being attached to the need of educating the public to become smoke conscious, and rightly so, Education in that regard was an important factor, but they must remember it was a factor only. *We could never hope to attain atmospheric purity by education measures alone.* Restrictive and compulsory legislation was essential, and he was confident that if the scheme put forward by Mr. Gandy could be brought into effect that considerable advantage would accrue.

Speaking on Mr. Acfield's paper, Mr. Priestley said this referred to the possible deficiency in ventilation of habitable rooms where heating was either central or by gas fires or electric radiators. He had omitted to mention the use of the open window as a means of ventilation.

For the last four years his office had been centrally heated and he had been able to obtain ample ventilation by means of open windows. In cold weather use was made of the Hinckes Bird window ventilator. In warmer weather the windows were opened much wider in accordance with the atmospheric temperature.

Mr. H. L. Pirie (Coal Utilization Council) said that Mr. Gandy stated that "no prohibition of smoke from the domestic fire is possible, or, in present conditions, desirable." That does not mean that the Society should not make any endeavour to reduce smoke from the domestic fire; and, indeed, Mr. Gandy himself went on to suggest voluntary adoption of smokeless substitutes.

The point he would like to have brought out was that the use of smokeless substitutes was not the only path towards smoke abatement, which would also be achieved by perfecting methods of burning ordinary bituminous coals smokelessly. During the last two years the Coal Utilization Council had been engaged in research work with that object; and they had ascertained first, from careful experiments carried on at the Fuel Research Station at Greenwich, that the bulk of the smoke from the open fire was given off during the ignition period; and secondly, that by the introduction of a special ignition device, which was now on the market, that ignition smoke could be reduced by anything up to 40 per cent., according to the type of coal used. He was informed by Mr. Heywood, the Housing Director of the Manchester Corporation, that he had decided to instal these self-lighting smoke-reducing fires in 20 new houses which were being erected on the Crossacres Estate.

That, he suggested, was a considerable step towards smoke abatement, although they should bear in mind that they could not expect to solve in a period of a few months a problem that has been neglected for 600 years.

In view of this research, and of the progress already made, it appeared therefore that smoke abatement did not necessarily mean the abandonment of the use of bituminous coals, and that in fact "anti-smoke" need not be synonymous with "anti-coal."

Mr. Philip Honey (British Electrical Development Association) said it was only fair to state that where electric power stations were being erected in thickly populated areas, the treatment of chimney effluent was such that it not only prevented grit and soot emission, but also dealt with sulphurous fumes as well—Battersea and Fulham Power Stations were examples. To be logical, all large central heating plants fired with fuels containing an appreciable amount of sulphur should receive similar attention. In a large city, atmospheric pollution was not wholly the result of sooty particles, and the effect of large isolated heating plants

should be considered from the standpoint of the effect of sulphurous flue gases upon surrounding buildings.

Concerning the ventilation of living rooms he thought that the disadvantages of both the air brick and the chimney flue in bedrooms was that they were both liable to be closed by the occupier, being stuffed either with newspaper or pasted over with paper whenever a draught was experienced. The flue also was only really effective when a fire was burning at its base. As it was logically right to extract foul air from a room at ceiling level, it was interesting to know that ventilators fitted to the lighting fittings had been successfully used. This made use of rafters as air ducts, prevented down draught and could easily not be closed by the occupier. Whatever the method of heat used, ventilation should be considered entirely as a separate problem, and reliance should not be placed on the flue for this purpose.

Mr. J. E. Acfield, replying, said that he was responsible for housing at the time domestic ranges burning coke were introduced by the Leeds Corporation into houses on their housing estates, but he was not now responsible and could not personally give complete answers; the following answers to Mr. Farquharson were partly the result of the experience of the Housing Director :—

(1) Copper. The Housing Director informed him that they were protected by an L shape wrought iron plate on the front and bottom and no difficulties had yet been experienced.

(2) See answer to (1). (3) The answer was in the negative.

With regard to four storey tenement flats, the Housing Committee of the Corporation of Leeds was introducing coke fires in their flats, some of which had as many as eight storeys.

Mr. Charles Gandy, replying, said that it was not the source of smoke but its emission which was harmful to the public, and that was equally so whether the source was industrial or non-industrial, the only difference being that so far legislative control of factory smoke had been easier than in the case of that from other sources. By making smoke from certain other sources, e.g. in central areas, a statutory offence, the position of local authorities in dealing with factory smoke would be strengthened, and as progress towards a completely smokeless city was made, decent citizens would conform to the higher standards without actual compulsion. Most people were prepared to play the game according to the rules, when those rules were in the common interest, but it was generally better to have those rules written and authoritative. Discussion of the proposals in city councils would have the useful effect of bringing information about the smoke nuisance before councillors who had not previously considered it. Railway smoke in central areas was rather a special problem, and while he agreed with Mr. Farquharson that it required immediate consideration, he did not see why smoke from other sources should not be tackled at the same time. Probably the real cure for railway smoke lay in electrification, but much could be done by the Railway Companies responsible, and the Society had already taken the matter up with those concerned.

Friday Afternoon, 1st October, 2nd Conference Session.

The Regional Committees.

Introductory Remarks by the Chairman, Councillor G. H. Kitson.

In introducing the speakers Councillor Kitson referred to the fact that he was Chairman of the Leeds Gas Committee a Vice-Chairman of the National Gas Council, and a member of the Leeds Electricity Committee. He mentioned the great progress that was being made in Leeds in the use of smokeless fuel, and the success that was meeting the efforts of the Gas and Electricity Departments in selling more gas and gas appliances in the increasing sales of electric current.

In calling upon the speakers Councillor Kitson announced that Dr. Clark's paper would be presented in his absence by Mr. Gandy, Alderman Adams's paper by Mr. Marsh, and Councillor Asbury's by Mr. Law.

Manchester and District Regional Smoke Abatement (Advisory) Committee.

Dr. R. VEITCH CLARK, Hon. Secretary,
Medical Officer of Health, Manchester.

This Committee was formed at the instance of the Ministry of Health in 1924 and has therefore been functioning for 13 years. It is obvious, therefore, that sufficient time has elapsed to enable a reasoned judgment to be made as to the efficiency and scope of work open to such a body.

The mere establishment of regional committees is of essential value inasmuch as it is an official recognition of the fact that the existing administrative activities of local health authorities have not been able to control the smoke nuisance. It is further an admission that with the existing organisation of local administrative areas effective control is not possible. I wish to stress these two points as they are in my opinion fundamental to the whole issue.

The Regional Advisory Committee has been of the greatest public value. It has directed public attention to the existence of the smoke nuisance from quite a new angle and by the affiliation of many local authorities has spread, and is continuing to spread, the conviction that joint action is essential.

Throughout its existence the Committee has dealt with a great number of matters and it is clearly impracticable to give even a summary of all of these now. We have taken steps to encourage standardization of smoke administration throughout

the whole of the regional district—thus the Committee have circularized the local authorities as to the adoption of the patrol system of inspection and a standard definition of black smoke, as to the maximum time concession for emission of black smoke, the advantages in practically all areas of having byelaws for the control of smoke nuisance, the adoption of draft byelaws, the qualifications and experience desirable in men holding the position of smoke inspector, etc. In addition, the Regional Committee has for over five years been responsible for the organization of classes for the training of stokers and boiler attendants, both in an elementary and a more advanced course of study. Certificates of efficiency are awarded by the Regional Committee upon the results of the examinations held. These courses are held in Manchester at the College of Technology and also at Warrington. The Committee has also taken an active part in propaganda work throughout the whole of South-east Lancashire directed towards the support of the campaign for the abolition of the smoke nuisance and has co-operated with the National Smoke Abatement Society in this matter, more especially in the issue of literature. At a great number of exhibitions the Regional Committee has co-operated with the Manchester Public Health Department in providing exhibits illustrative of smoke production and smoke abatement. The Committee also works in close association with other public bodies such as the Ministry of Health through His Majesty's Inspector of Alkalis, The Federation of British Industries, the Coal Utilisation Council and many private bodies interested in the subject.

This mass of work, continued as it has been during these 13 years, has undoubtedly affected public opinion and made a considerable contribution towards the realization that the atmosphere should be as clean as our water supply and in stimulating the public demand that steps should be taken to attain this desirable object within a reasonable period of time.

It is not forgotten that enormous improvements have already taken place during the past 25 to 30 years, due to many causes, but it is equally true there still exists a degree of pollution which is a reproach to any civilized community.

Fairly early in its existence the Committee realized that, as an advisory body, it had not the power to improve the administration of existing smoke law in an area and its attention was therefore directed to the investigation of the advisability of endeavouring to establish a statutory body which would control smoke nuisance in an area corresponding to that which the Advisory Committee represented. The Committee caused a series of observations to be taken throughout the whole of the area and the facts thus obtained convinced the representatives that only by the formation of a joint statutory body instead of

the Regional Advisory Committee could we hope to get a really effective administration of the law in such an industrial region as that which the Regional Committee covered in its constitution.

I therefore direct especially the attention of this conference to the work which has been done by the Manchester and District Regional Advisory Committee towards the establishment of a statutory smoke board for the regional area. Some years ago the Regional Committee did definitely approve a formal scheme for the establishment of such a board and this was, with very few dissentients, approved by the representatives of the areas constituting the Regional Committee. On reference, however, to the local authorities the representatives, apparently, were not able to carry it through and the proposal was defeated in so far as its general acceptance was concerned. There is no doubt but that two causes operated towards this initial reverse in policy; the first undoubtedly is the lack of realization by local authorities that smoke nuisance is a widespread thing and is not confined to the limits of the area of production and that therefore only by wider control is effective abatement practicable. The other reason is the age-old one of local pride and a quite understandable jealousy of interference with existing powers. This mental attitude must be met and overcome.

In 1935 the Regional Committee again put forward a proposal to form a joint statutory board for South-east Lancashire and again this was approved, and approved unanimously, by the representatives at a full meeting of the Regional Committee. Since that date on the instructions of the Committee the Chairman and Honorary Secretary (Alderman Jackson and the writer of this paper) have visited many of the constituent bodies and have received a formal assurance from practically all the authorities visited that they will support the proposal to form a joint board. It is hoped that during the present winter the time will be ripe to take definite steps towards the formation of a joint board consisting of a sufficient number of authorities to justify approach to the central Government authority for a provisional order.

There is no need in this gathering to stress the disadvantages of the smoke nuisance or the advantages of its abatement, either in the direction of health and economic efficiency, of the preservation of buildings and of the actual fruitfulness of the agricultural regions in the neighbourhood of towns, but it is important that this assembly should know the overwhelming facts, even in a very brief way, which have convinced our Regional Committee that a statutory joint board is needed. I would recommend anyone who desires it to read the report prepared by the Regional Committee for this purpose. It is to be found in the Annual Report of the Health of the City of Manchester for 1935, pages

449 to 457. If this volume is not available to anyone there are still some copies to be had on application to the Honorary Secretary of the Manchester Regional Smoke Abatement Committee, Public Health Department, City of Manchester.

The Committee had a specific survey made of smoke emission in 33 of the districts in the region and these were compared with the results in the city of Manchester, not because Manchester is specifically considered to be so much better than the neighbouring districts, but because for 40 years the smoke clauses have been administered as fully as has been practicable in the city. The results are given in the following tables:—

TABLE I
COMPARISON OF MANCHESTER'S SMOKE AND THAT OF THIRTY-THREE
NEIGHBOURING DISTRICTS

District	Year	Number of half-hourly observations	Number of working days necessary to obtain these observations	Average smoke per half-hourly observation in minutes		
				Dense Black	Moderate	None
Manchester	1929/30	723	1,300	1·8	13·5	14·7
	1933/34	455	1,178	2·3	15·7	12·0
	Average	589	1,239	2·0	14·4	13·6
33 other local authorities within the Regional Area	1929/30	542	42	9·2	13·2	7·6
	1934	455	34	7·8	16·1	6·1
	Average	499	38	8·6	14·5	6·9

TABLE II
SHOWING IN PERCENTAGES THE HALF-HOURLY PERIODS IN WHICH DENSE
BLACK SMOKE EMISSIONS OCCURRED AND THE DURATION OF EACH EMISSION

District	Year	Percentage showing less than 2 minutes emission	Percentage showing 2 to 5 minutes emission	Percentage showing 5 to 10 minutes emission	Percentage showing 10 to 20 minutes emission	Percentage showing emissions of 20 minutes and upwards
Manchester	1929/30	71·3	15·8	11·1	1·5	0·3
	1933/34	68·3	20·7	8·6	2·0	0·4
	Average	70·2	17·7	10·1	1·7	0·3
33 other local authorities within the Regional Area	1929/30	3·7	20·3	38·3	32·5	5·2
	1934	6·4	26·4	38·6	24·2	4·4
	Average	4·9	23·1	38·5	28·7	4·8

The results of the observations have been averaged in these tables and it will be seen that they are two separate periods of observation—1929-1930 and 1933-34. Summarized they show that the emission of dense black smoke in the 33 districts was over 25 times as frequent in occurrence as in Manchester. This is not a criticism of local administration anywhere but is simply given as showing the improvement that results from constant observation and control of smoke emission. Again, in the 33 districts only 4.9% of observations gave less than two minutes emission of dense, black smoke in the half hour, whereas in Manchester the corresponding percentage is 70.2. These results are stressed equally strongly in Table II,

The conclusion obviously is that the existing legal powers are not being made use of to the extent which is possible in many areas. Again, this is not a criticism of administration because in a great proportion of these districts the financial resources make it impossible to appoint a properly qualified inspector for the purpose. The existing sanitary inspector, or inspectors, have so many other duties that no time is available for adequate smoke observation and control. It is the fault neither of the authority nor of the inspector. This is true in many instances but in other cases there is no doubt that the authorities have not applied the powers given by Parliament as they should do.

Sixty-two years have elapsed since the 1875 Act gave very considerable powers of smoke abatement and still we have such results as these. Unquestionably there is something wrong with the local machinery.

The relatively good districts suffer for the sins of commission and omission of bad districts and it is only by unifying statutory control that this difficulty can properly be surmounted.

A further very great advantage of a larger body such as a joint statutory board would be that qualified, technical advice, i.e., advice of trained fuel engineers, could be made widely available to manufacturers and other persons so that they may be properly and wisely advised as to fuel consumption and the practice of the use of fuel in the most hygienic, as well as the most economic, manner. A later page in the Regional Committee's report (page 454) gives nine examples of the saving effected in consequence of such advice which has been given to firms in the city of Manchester. It is a definite advantage to the coal consumer that such advice should be available and free of cost. Industry would benefit as well as the health of the people.

There is a parallel in the formation of joint rivers boards. There is no doubt but that many of our rivers are still highly polluted, but the difference in the pollution of the present day and that in existence before rivers boards were formed is very great. Our atmosphere is at least as important as our river waters. We always use the one, the other we may or may not use. In any event, we depend upon a pure air for clean and healthy bodies. We depend upon a proper, economic use of coal for the conservation of our fuel reserves. Common sense, as well as the need of human happiness, impels us to do what we can towards the mitigation of a nuisance which is a reproach to this country. Any step which will help towards the removal of this reproach should be taken vigorously and we believe that the formation of a wider statutory body such as that which is advocated by the Manchester and District Regional

Advisory Committee is one of the most important means at our disposal now. I therefore commend this, with the greatest impressiveness at my command, to the serious attention of this conference.

The Midlands Joint Advisory Council for Smoke Abatement and

Comments on Establishment of Statutory Committees.

by MATTHEW BURN, M.C., M.M., F.R.C.P., D.T.M. & H.,
D.P.H., Deputy Medical Officer of Health, Birmingham,
Honorary Secretary.

The above Council was formed in the Autumn of 1927, and is composed of representatives of 50 local authorities, 8 being County Boroughs, 10 Boroughs, 20 Urban Districts and 12 Rural Districts, which are situated in an area having a radius of approximately 25 miles, with Birmingham as the Centre. Since the date of its formation its Executive Committee has been in continuous touch with problems of smoke abatement. Information was obtained from each district as to the works using steam raising plants, the number of chimneys attached to works within each district, the procedure in regard to systematic observations and the duration of such observations, the aggregate permissible allowance of black smoke, the procedure in regard to legal proceedings and other kindred information.

After consideration of these data the Council advised its constituent authorities to adopt bye-laws respecting the emission of black smoke and eight authorities acted on that advice. Birmingham itself adopted the standard of three minutes emission of black smoke in 30 minutes, but all brick kilns other than "top fired" ones were excluded for a period of 3 years. These now come within the scope of the bye-law.

While the Act of 1926 has proved valuable in encouraging the adoption of such bye-laws, its value cannot be judged solely by the extent to which they have been adopted. There can be no doubt that it has stirred industry in many directions to take more direct concern in the question of smoke abatement in the interests both of industry and health of the community.

The Council have also had under consideration the question of action under Section 5 of the 1926 Act under which byelaws may be made in respect of new buildings. After full consideration, however, it was felt that the wording of the Section was such as to make impracticable the effective adoption of any suitable bye-laws.

Other activities of the Council included the provision of training classes for stokers, but unfortunately it was found impos-

sible to carry these on owing to the inability to obtain stokers to attend.

In 1929 the Council made arrangements for the services of an Engineering Expert to be available for the constituent authorities for advice on smoke abatement. The adviser was paid a retaining fee on behalf of the area as a whole, constituent authorities needing his services, thereafter paying a separate reduced fee, depending on the extent of the service required. Close co-operation exists between the Executive Officers of the Council and the representatives of the F.B.I., who at all times are willing to give their help in any problems which may arise.

It may be said in general that the M.J.A.C. is a valuable co-ordinating body towards the education of Local Authorities in the area in the direction of interest in smoke abatement, and towards a greater degree of standardisation of their work, while avoiding the dangers inherent in any attempt to force too even a standard of uniformity on areas varying considerably in their circumstances and needs.

I should at this point like to mention a measure put into effect in Birmingham which I feel sure will prove a valuable contribution towards the abatement of atmospheric pollution. I refer to arrangements made between the Public Health Department and the City Surveyor's Department whereby plans of new industrial buildings and chimney stacks, which are deposited with the latter Department for approval, are passed on to the former Department for their observation. By this means records of new and various types of plant, together with the height of their chimneys, are kept and the depositors are interviewed, and when necessary advice given as to the alteration of plant, etc., in order to obviate excessive smoke emissions.

Another measure of great benefit is the arrangement that outside contractors doing Corporation work shall use anthracite or other smokeless fuel.

Statutory and Advisory Committees.

Whichever views are held by individuals as to preference being given to the establishment of one or the other of the above committees, I am sure we are all agreed that the fundamental principle involved in attempting to abate atmospheric pollution is to effect a close and active co-operation between the officials of the Local Authority and the manufacturers themselves, after which the duty of the smoke inspector resolves itself into one of advising and assisting the manufacturer, who, if approached in this amicable spirit is always inclined to reciprocate it with a desire to improve his plant and eliminate smoke nuisance.

Accepting this principle one must realize, as all who are engaged in the variety of activities associated with public health

I am sure do, that legislation and Acts of Parliament will *not* in themselves contribute much towards smoke abatement. Indeed I am unaware if any further legislation is in fact necessary as advocated by certain sections interested in the abatement of atmospheric pollution. For instance, discussions have taken place in regard to the advisability of determining the list of qualified exemptions under the Public Health (Smoke Abatement) Act, 1926, and I believe direct approach was made to this end to the Minister of Health by the one Statutory Committee in effect in this country.

Let us for a moment read carefully the wording of Section I (e) of the 1926 Act, coupling with it Section 334 of the 1875 Act, and we note that these metallurgical processes are *not* in fact exempted so long as the remedial measures do not hinder the efficiency of these processes. Does not the said Statutory Committee in fact imply in its request for such exemptions to be determined, that the process *can* be carried out without production of smoke nuisance and without interfering with the process? I fail to see in this any argument for a Statutory Committee which appears to read its powers in a more restricted sense than does such an Authority as, let us say, Birmingham, working as a member of an Advisory and not a Statutory Committee. This does not tempt me to lean towards the establishment of statutory committees throughout the country. Similarly I consider as of a negative character the proposal for the establishment of a Manufacturers' Committee to which are to be referred these cases of nuisances from metallurgical furnaces. Why not use the powers which we have rather than clamour for additional weapons when we are not working those which we already possess? It has been stated that there is no true difference between statutory and advisory committees, the difference being only in the powers which the Local Authority choose to delegate to the Committee. If a Local Authority is not at present exercising its full powers, is the mere formation of a Statutory Committee likely to make it do so? Such appears to me to be mere assumption, and I have yet to hear, after some years of discussion of this so-called problem, of any advocacy of a practical nature for the establishment of statutory committees. I am of the opinion that the means already at the disposal of Local Authorities allows the work to be carried out efficiently. To add further legislation, or in this case to delegate the powers already possessed to another committee, appears to me to be avoiding the problem. I should myself deprecate any such delegation which would be to the disadvantage of those Local Authorities, which in their existing powers have established that close and effective co-operation with manufacturers, on which sound action towards industrial smoke prevention must depend.

(Summary).

Northumberland and Durham Advisory Regional Smoke Abatement Committee.

By ALDERMAN DAVID ADAMS, M.P., J.P., Chairman.

History of Formation.

In October, 1927, a conference was held in Newcastle upon Tyne to consider how the problem of atmospheric pollution might be tackled on Tyneside. Invitations to attend were confined to authorities on Tyneside only, seventeen in number, of whom thirteen were represented. The conference passed a resolution approving the proposal to establish a Regional Smoke Abatement Committee for Tyneside, and a constitution of committee was drawn up for consideration. At subsequent meetings, however, there was a difference of opinion as to the method of allocation of expenses, and in 1929 it was decided that in view of the lack of unanimity displayed by the authorities concerned consideration of the formation of a Regional Committee be postponed.

In May, 1933, following a suggestion from the National Smoke Abatement Society, a conference was held in Newcastle upon Tyne to which all authorities in Northumberland and Durham (fifty-four) were invited to send representatives, and a resolution to establish the Northumberland and Durham Advisory Regional Smoke Abatement Committee was carried. (Large authorities who did not join were Stockton, Wallsend, Gateshead, Tynemouth and West Hartlepool.) Twenty-four authorities became members, and at the present time twenty-two are represented.

Appointment of Smoke Inspector.

In 1934 the Regional Committee recommended to its constituent authorities that a Smoke Inspector be appointed to cover their areas, the cost to be borne by the authorities proportionately on a basis of rateable value. The estimated cost to the Committee was £400, of which Newcastle upon Tyne's share would be approximately £180. With four exceptions the constituent authorities agreed to the proposals, but in the case of Newcastle upon Tyne the recommendation failed to pass the Council. Without Newcastle's contribution it was impossible for the Regional Committee to appoint an Inspector, and the proposal was dropped.

Byelaws re Smoke Emission.

In 1935 the Regional Committee recommended to its constituent authorities that they should use the powers invested in

them under the Public Health (Smoke Abatement) Act, 1926 (Sec. 2) to formulate byelaws regulating the emission of black smoke. As a result of this no fewer than eight authorities have now such a byelaw in operation.

Smoke from Burning Pit Heaps.

The nuisance created by burning pit heaps was constantly before the Regional Committee, and at the last Conference of the National Smoke Abatement Society the following resolution was moved on its behalf :—

“That this meeting of the National Smoke Abatement Society begs to draw the attention of the Minister of Health and of Members of Parliament for the areas affected to the serious nuisances caused by burning pit heaps or colliery spoil banks; and, being of the opinion that, as for example instanced in the last published Report on Alkali, etc., Works, measures for both the abatement and the prevention of such nuisances are practicable, expresses the desirability of legislation which will (a) permit the abatement of existing nuisances, and (b) enable new pit heaps to be so controlled that such nuisances will not arise.”

In a reply the Minister of Health promised to give the Resolution careful consideration.

Courses of Instruction for Firemen and Boiler Attendants.

Prior to the formation of the Regional Committee classes for the training of firemen had been run at Rutherford College, Newcastle upon Tyne, in 1930-1 and 1931-2, but lapsed for two years owing to lack of support. In 1934, however, the Regional Committee were successful in recommencing these classes, with satisfactory results. In 1935 an attempt was made to run a course on the syllabus of the City and Guilds of London Institute which covers two years instruction, at the end of which students who are successful in the examination are granted the Certificate of the Institute which is universally recognized. Only six students enrolled, however, and the project was dropped. The following year the former course of training was reverted to. Since the commencement of these courses 134 students have attended and local certificates have been granted to 85. The cost of the course is 7/6d. and consists of twelve lectures and eight practical demonstrations. It is hoped, if the demand warrants it, to start courses at centres in Durham County.

Circulation of Literature.

The Regional Committee has on occasions circulated to its constituent authorities literature on the various smoke preventing apparatuses and smokeless fuels which have been brought to its notice.

Health Week.

A circular letter was addressed to authorities in Northumberland and Durham asking them to take into consideration the question of smoke abatement if or when they formulated a programme for Health Week.

Addresses.

Papers have been read to the Regional Committee on various aspects of the atmospheric pollution problem by Dr. J. T. Dunn, the Public Analyst for Newcastle upon Tyne, Mr. F. J. Dyer, Asst. Chief Sanitary Inspector for Sunderland, Mr. Arnold Marsh, General Secretary of the National Smoke Abatement Society, and Mr. G. S. McIntire, Town Clerk of Sunderland.

Visits.

A visit was paid by the Regional Committee at the invitation of the Chairman of the Sunderland Health Committee to various businesses in Sunderland where smoke eliminating apparatus was installed.

Annual Subscription.

In view of the small financial commitments of the Regional Committee it was decided in 1936 to reduce the annual subscription from £2 2s. 0d. to £1 1s. 0d.

The Sheffield, Rotherham and District Committee.

By Councillor W. ASBURY, J.P., Chairman of the Committee.

Sheffield, Rotherham and District Smoke Abatement Committee is the only Executive Regional Committee in Great Britain, and it has been in operation since May, 1930—a period of over seven years.

The question of Regional Control has been written about and discussed to such an extent that it would appear to be a waste of my time and yours to reiterate the whole scheme from start to finish. For the benefit of those who are not conversant with this method of control, I will briefly state how the Committee commenced to function, the difficulties peculiar to the area, the progress that has been made and the economic factors that have a considerable bearing on the subject.

When the Public Health (Smoke Abatement) Act, 1926, came into operation, Sheffield and Rotherham were of the opinion that it would be desirable to have uniform control, and a Joint Smoke Abatement Committee was formed for this purpose in July, 1937.

After two years' working they resolved to extend the Area and four other local authorities were invited to combine with them for this purpose. Three of these authorities, Rotherham Rural, Rawmarsh and Greasboro, agreed, and the Sheffield, Rotherham and District Smoke Abatement Committee was formed. It consists of five members from Sheffield, two from Rotherham and one from each of the smaller constituencies.

The Committee meets once a month and the work of the Smoke Abatement Staff is reported to this Committee, who decide whether notices shall be served or proceedings shall be instituted with regard to these reports.

Joint Advisory Committee.

In addition, a Joint Advisory Committee consisting of members of the Manufacturers' Association and the Smoke Abatement Committee was inaugurated in May, 1928, to discuss the difficulties of smoke due to the manufacture of steel and iron, which is the principal industry in the area.

It consists of five members of the Manufacturers and five members of the Smoke Abatement Committee, with a Professor of Fuel at the University as the Chairman.

The Committee meets every six months, when progress reports of the research work which is being carried out are submitted and difficulties of working that have arisen are discussed.

Staff.

There are five Inspectors on the staff, all of whom are engineers with experience in combustion work, and capable of advising the manufacturers with regard to their difficulties, also of instructing the firemen with respect to the best methods of charging and controlling their furnaces. Four of them are appointed on the Health Department Staff of the Sheffield Corporation, the other being appointed on the Rotherham Staff, and are loaned to the Smoke Abatement Committee for the purpose of carrying out this work. This arrangement has proved quite satisfactory.

Area.

The area, which covers about 123 square miles, is divided into four districts and the total number of chimneys is about 3,900. At first there was some difficulty with regard to allocation, but by gradual adjustment this has been overcome and routine inspection of all chimneys is carried out each month.

It has not been practicable to number each chimney, but a number is given to each works and the chimney a special designation. There are works in the area with upward of 100 chimneys.

When reports are made to Committee for prosecution work, only the number and designation of the chimney are given. In this manner the difficulty of vested interest which in some smaller districts is strong can to an extent be ruled out, because the Committee are not aware of the ownership of any chimney.

When the work commenced the average smoke emission per chimney showed 13·2 minutes per hour in Rotherham Rural District and 8 minutes per hour at Rawmarsh, and for over four years these emissions fluctuated to a considerable extent though never reaching that peak again. During this period reconstruction work was being asked for, and in some cases being pressed, and though the work was slow it was eventually carried out almost in its entirety. The past two years show average emissions of about 3·5 minutes per hour, which shows the advantage of advisory methods, systematic observation and uniform control.

We are not yet satisfied with this average, for the figure aimed at should be about 1·5 minutes per hour and the pressure will be continued in certain cases.

Research Work.

We claim to be the only local authorities who, in conjunction with the local manufacturers, have carried out research work for the purpose of smoke abatement. When the Joint Advisory Committee held their first meetings, it was the contention of the manufacturers that the various processes necessary in the manufacture of steel could not be carried out without the emission of excessive smoke, this being a necessary factor in order to prevent excessive scaling and decarbonization of the material. We were not in a position to contradict these statements, but it was agreed that research work should be carried out in order to investigate the possibility of overcoming the difficulty. Certain works in the district were also investigating the same problem. After three years' work, in June, 1933, it was stated by the Chairman of the Joint Advisory Committee that "providing suitable plant is used, metallurgical processes can be carried out without the emission of excessive smoke, but that the manufacturers could hardly be expected to scrap existing plant which had cost thousands of pounds to instal."

Research on process work was discontinued, but further work on smoke abatement problems took its place. Research work on the behaviour of industrial coke from coke ovens in various types of domestic ranges was carried out and the blending of various kinds of coal in order to produce a suitable coke for domestic use was tried.

Later the classification of boiler fuels in use in the area by analysis and by large-scale trials on Lancashire boilers was commenced. This work is still in progress.

The cost of research was originally borne by the manufacturers and the Smoke Abatement Committee paying equal shares, with a yearly grant from the Department of Scientific and Industrial Research, but latterly the major portion of the cost has been undertaken by the Smoke Abatement Committee. During the "slump" period, the manufacturers asked for this work to be discontinued, but the Smoke Abatement Committee were of the opinion that it should continue. The cost of the work to the Committee is about £200 per annum.

The result of this has enabled the Committee to make application to the Ministry of Health requesting them to reconsider the provisional exemption granted to process chimneys in 1926, and it is hoped that this will take place at an early date.

The remarkable feature of this work appears to be that comparative smokelessness can be obtained when using almost any type of fuel from controlled furnaces that work at reasonably high temperatures.

Low-temperature furnaces—principally used in heat treatment work—are only successful when using gaseous fuel and electricity, though progress has been made recently with the use of pulverized coal.

Expenditure.

When the Committee was formed the estimated expenditure was assessed at £2,500 per annum, of which each constituent authority contributed its quota according to its rateable assessment. The first year's working cost £1,607, which was considerably below the estimate. Last year the expenditure was £2,120, the cost to the smaller authorities being only a nominal sum in comparison to Sheffield. Stocksbridge paid £21/18/- and Rawmarsh £37/10/- for their quota of control, which averaged about 15 pence per chimney observation. It can definitely be stated that the most successful part of Regional Control is the economic factor. Small authorities cannot afford to pay for work of this kind, but with the co-operation of the larger surrounding authorities uniform control can be carried out at a very small cost.

Conclusion.

Many people will state that the pollution of the atmosphere is decreasing, but statistics and visual observations of anyone interested in this subject will show such is not the case except in one or two isolated areas.

With the general improvement of trade conditions throughout the country during the past two years, the amount of pollution, particularly in industrial areas like Sheffield, Rotherham and District, has shown a very decided increase. We are not

flattering ourselves that we have cured all our smoke troubles: there is work and reconstruction to be done in plenty. We have proved that metallurgical processes can be carried out with a minimum of pollution, providing the manufacturers will use suitable plant, and that there is no necessity for any qualified exemptions in our smoke legislation. We have shown that goodwill and co-operation are essential factors in this work if progress is to be made. Regional smoke control with qualified Inspectors to carry out the work is the only rational method of dealing effectively with this evil which otherwise will continue to be a disgrace to a civilized community like ours. Small local authorities cannot deal effectively with the problem on account of cost and it is incumbent on the larger authorities throughout the country to take the lead in this matter. I would like to make an appeal to all representatives of local authorities to consider this matter, to forget about the larger authorities wishing to take control, but to aim at a system of controlling a nuisance which can be obviated without any loss of dignity and at a nominal cost to the individual.

The West Lancashire and Cheshire Regional Smoke Abatement Committee.

By W. M. FRAZER, M.D., Ch.B., M.Sc., D.P.H.,

Honorary Secretary, Medical Officer of Health, City of Liverpool.

The present tendency in local government is towards the federation of authorities for specific purposes and the extension of this principle with regard to smoke control is highly desirable, smoke abatement being essentially a regional business. It was the good case presented by the National Smoke Abatement Society that influenced the formation of the West Lancashire & Cheshire Regional Smoke Abatement Committee in April 1933. The representation of this committee, although industrially not of extensive proportions, covers a wide area and consists of twenty local authorities. An Executive Committee was appointed whose aim, during the four years' working, has been to keep a just balance when considering the various possibilities and methods of achieving its object, the avoidance and abatement of the pollution of the atmosphere.

To ascertain the type and extent of pollution in the area a preliminary survey was conducted, by means of questionnaires, to all the constituent authorities. It was found that there were approximately 1,300 industrial chimneys, a population of $1\frac{3}{4}$ million people and 400,000 domestic houses, the principal industries being shipping, shipbuilding, engineering, sugar-refining, soap making, flour and seed milling and chemical manufacture.

Following the consideration of this and other data regarding bye-laws and difficulty of administration, grit emission, use of electricity and kindred information, the Committee circularized its constituent authorities urging the adoption of bye-laws respecting the emission of black smoke.

Throughout the area great interest was stimulated in the subject. Smoke inspectors were appointed by two authorities, whilst in others the multifarious duties of the Sanitary Inspector were added to by routine observations of factory chimneys.

There are few exempted industries in the area and the main industrial smoke question concerns boiler smoke. Many of the large firms are solving their smoke problem satisfactorily; in their endeavour to reduce power costs, efficiency is demanded in the boiler-house, and this has led to the installation of mechanically-controlled, modern boiler-plant, with the consequent general cleaning-up of the industrial chimneys. There is also a steadily increasing demand for combustion engineers by large manufacturers which has resulted in skilled supervision and satisfactory results being obtained from the boiler-plant available.

In keeping with a policy of forceful propaganda the Committee published a well-compiled handbook on Smoke Abatement and Fuel Economy in Industry. Nearly one thousand copies of this handbook were sold and distributed to manufacturers in the area.

Lectures on Smoke Abatement and Fuel Economy.

Recognizing that technical advice and instruction is essential for boiler-plant owners and operators so that they might put into practice the principles on which fuel combustion, furnace management and boiler efficiency should be carried out, the Committee, in collaboration with the University School of Hygiene, Liverpool, established a series of lectures and demonstrations. The classes were designed for works managers, engineers, boiler attendants, and for those officials of local authorities whose duty it is to deal with smoke nuisances, so that they might receive adequate instruction, both theoretical and practical, in the subject. During the last four years there has been an average attendance of over 80 students and many firms in the area are co-operating, as apart from the interests of a cleaner atmosphere it is in the employers' economic interest to facilitate and encourage the attendance of their men. These lectures and demonstrations are complementary to the general work of administration, and care is taken that the syllabus is not too academic for its purpose. Great interest is shown by the students in the practical demonstrations, which are usually held on Saturday afternoons. Visits are made to such places as the electricity generating stations, gas works and factories and steamships where good fuel combustion conditions obtain.

Records of Pollution.

To ascertain the amount of pollution in various parts of the area and to secure means of measuring the degree of success of any improvement measures, the Committee has encouraged the larger constituent authorities to establish Standard Deposit Gauges. As a result of its efforts in this direction there are now ten stations in use throughout the area and regular observations are being made where previously facilities for this purpose did not exist.

Smoke from Railway Engines.

One of the most serious of the present-day smoke nuisances arises from railway locomotives. Smoke emission from individual engines may not be black or excessive but the sulphurous fumes and smoke discharge from railway tunnels, cuttings and ventilating towers in the centre of towns constitutes a menace to the health of the inhabitants and causes discolouration and deterioration of property in the immediate vicinity. Most towns suffer in this respect.

In the Merseyside area attention has been given to this matter, and, as a result of a deputation to the L. M. & S. Railway Company, negotiations are now proceeding between the railway company and the authorities concerned.

Domestic Smoke.

The smoke from domestic chimneys constitutes the major part of atmospheric pollution in the area and efforts have been made to abate this important factor in the problem. The practicability of making available to the public smokeless fuels (including gas and electricity) at a reasonable cost was carefully studied by the Committee. Suggestions were made to those constituent authorities with gas undertakings to increase the output of coke and improve its quality so as to make it suitable for use in the ordinary household grate. Satisfactory solid smokeless fuels are manufactured in the area and have a large and steadily increasing sale. Encouraged by this demand for smokeless fuels the Housing Departments of the various large authorities were approached regarding a scheme to erect smokeless houses on new estates but public and official apathy has been a great obstacle in these endeavours to bear on this most pressing problem. The agitation for smoke abatement, however, is emerging from its pioneer stage. The gas and electricity industries show in their returns that considerable progress is being made in heating and cooking by these smokeless mediums. Estates have also been developed, by private enterprise, whereby gas coke can be used in suitably designed firegrates. In general, progress in domestic smoke abatement is being made on the following lines :—

Future Developments.

- (1) The installation in new houses and offices of grates suitable for burning coke, together with inducements to use gas or electricity for cooking and for heating purposes in rooms where a regular fire is not required.
- (2) The conversion, where practicable, of ordinary open grates to a design suitable for burning any solid smokeless fuel.
- (3) The promotion of facilities for the sale of coke and other solid smokeless fuels in small quantities.

1. To consolidate the present position and stimulate greater interest there is need of a national effort in regard to advisory regional committees to link up and extend these movements.

2. There is necessity for uniformity of practice and administration in smoke abatement throughout the country.

3. The mass rate of emission of the pollution from domestic sources requires more forceful action.

4. In the case of large coal-consuming plants the acid constituents of the smoke are generally as objectionable as the solid constituents, and, as it has now been demonstrated that large power stations can operate economically after installing suitable plant for the treatment of flue gases, the extension of this system to other large installations is highly desirable.

With the exception of very large industrial areas, advisory regional committees have a very limited sphere of operations and in due course local authorities show a lack of interest. In some areas the opinion that smoke is the natural and inevitable concomitant of industrial and urban life still exists, and there is a general reluctance on the part of many local authorities to put into force any bye-laws against smoke emission. This can, perhaps, be understood as local authorities are trying by every known method to encourage existing and new industries, and do not feel justified in putting any obstacle in the path of manufacturers, consequently smoke emission is tolerated without protest in many districts. Manufacturers and the public require to have a reliable and impartial guidance on the general position of the use of fuel and atmospheric pollution and this must be directed by the Ministry of Health and the local authorities.

Although it cannot be claimed that the present smoke legislation is satisfactory, full use has not been made of existing powers and the position will remain unsatisfactory until all local authorities take active and uniform steps to abate the nuisance. The present position calls for central control so that the whole country may be placed on an equal basis.

In regard to domestic smoke, the authorities of the large towns are becoming such large landlords that the solution of this

problem will be to a great extent in their own hands, but it is to be regretted that up to the present full advantage has not been taken when making plans for the erection of corporation houses. Housing committees should consider the smokeless alternatives to the ordinary bituminous coal-burning fire grate. It would be an economic reform to make compulsory the installation of grates that are capable of burning coke as well as coal.

Much can be done to reduce the evil by teaching school children to regard coal as a raw material, and pointing out to them the destruction and above all, the ill effects produced on health caused by our forefathers regarding it as a finished product. In classes and training centres for hygiene and domestic economy, a greater diffusion of knowledge on smoke abatement would also be of material assistance.

Although it cannot be said that the Regional Committee has brought about any drastic change in the condition of the atmosphere in the Merseyside area, it has stimulated interest among the local authorities and excessive smoke is being controlled. The four years' working has been satisfactory and the industrial smoke problem is being energetically tackled by many authorities and success has been achieved. With the same energy and perseverance displayed on the domestic side there is no reason why another advance in the history of public health should not be achieved, but combined and sustained efforts are necessary to further this work of cleansing the atmosphere.

**West Riding of Yorkshire
Regional Smoke Abatement Committee.
1925-1937.**

By J. JOHNSTONE JERVIS, M.D., D.P.H., Honorary
Secretary, Medical Officer of Health, City of Leeds.

In May, 1925, a conference of the local authorities in a region including the greater part of the industrial area of the West Riding was called at the instigation of the Ministry of Health, to consider the question of smoke prevention with particular reference to the formation of a Regional Committee. Mr. J. C. Dawes, of the Ministry of Health, was present and occupied the chair. The special problems of the area were discussed at length and the delegates were all of opinion that there was an urgent need for improvement in the state of the atmosphere.

It was pointed out how the procedure with regard to the administration of the law relating to smoke varied throughout

the area. Some authorities had one standard, some another, while others had none at all. In some places prosecutions were taken freely: in others seldom or never. In no two places was the method of taking observations the same. It was obvious that order had to be introduced to end this chaotic state of affairs.

As a result of the conference an Executive Committee was formed with the M.O.H. as Honorary Secretary. The various groups of local authorities elected representatives and the proportion is now as follows: County Council, one member; County Boroughs, seven; Municipal Boroughs, four; Urban Districts, eight; Rural Districts, two. A further five members can be added by co-option, making a total of 27. The Executive Committee holds office for a period of twelve months until the holding of the next Annual Conference of constituent authorities.

The Constitution is briefly as follows: "For the purpose of improving the control of and reducing the smoke nuisance a conference shall be held annually . . ."

The objects shall be:—

- (a) To bring about a more uniform administration of the law in relation to the emission of smoke.
- (b) To standardize the methods of taking observations.
- (c) In consultation with the various Education Authorities to organize courses of training for stokers and boiler attendants throughout the area, to arrange for the holding of examinations in suitable centres and to issue certificates to successful candidates.
- (d) To secure a better understanding between local authorities and manufacturers.
- (e) With regard to propaganda.
- (f) With regard to research.
- (g) With regard to keeping of records of meteorological conditions and the state of the atmosphere.

Each year the deficit on the accounts is apportioned amongst the constituent authorities and the average contribution is below ten shillings per authority. The administrative costs are very low, but there is no impairment of efficiency.

The first action of the Committee after its constitution was to ascertain the state of affairs in the area, and in order to obtain this information a questionnaire was circulated to the local authorities. The information received was analysed and tabulated and it was then shewn how wide the differences were between the methods of the various authorities. The first year of the Committee's existence was occupied in dealing with this problem and devising means to bring about uniformity.

Then came the Public Health (Smoke Abatement) Act, 1926,

which gave local authorities power to make bye-laws regulating the amount of black smoke. The Committee did not feel satisfied with the qualification "black" and made representations to the Ministry of Health accordingly. However, a bye-law was drafted allowing a period of two minutes in thirty, which was circulated to all the constituent authorities and adopted by a majority of them. In one or two, however, it was opposed by certain manufacturing interests as a result of which a Government enquiry was held at Bradford in July, 1928, and three minutes was substituted for two. Since then, however, some of the authorities have succeeded in getting the limit reduced to the two minutes originally recommended.

Lectures and Examinations.

Before the formation of the Committee efforts had been made in at least one West Riding town—Huddersfield—to interest boiler-men in smoke abatement and to provide instruction in the theory and practice of boiler firing. A great deal of the smoke emitted from works chimneys was at that time, as it still is, due to inefficient operation of the boiler plant. The Regional Committee realized this and decided that the only way to remedy this was to train the men responsible for the handling of the plant. An Examination Board was formed and arrangements made for the holding of courses of instruction and examinations throughout the area and for the issue of certificates to successful candidates. The Education Authorities and the Yorkshire Council for Further Education gave valuable assistance and the scheme generally speaking had the support of the employers. For the first year or two the classes were a success, but just recently there has been a falling off in the numbers of students due it is thought to the apathy of employers and the reluctance of the men to spend time and thought in obtaining a qualification for which there is no monetary reward. This question of the payment of a higher rate of wage to men holding the Committee's certificate is one which has had and is still having the attention of the Committee. It is felt that until some sort of recognition of the stoker's efforts to equip himself better for his job is made only the very keen men will be attracted.

Since the commencement of the scheme the City and Guilds of London Institute has inaugurated an examination in boiler house practice. But this examination is more advanced than that of the Regional Committee and is intended for students who have already obtained the local certificate and wish to qualify themselves on a still higher standard. From the inception of the Regional Committee's scheme in 1930 up to the end of last session (March, 1936) the number of men who had taken the classes and obtained the certificate reached a total of 320. Not all of these are engaged at the boiler front, some are engineers and technicians,

but the majority are men whose daily occupation is to shovel coal on to a boiler fire.

Observations of soot fall, daylight and atmospheric sulphur are taken by several of the constituent authorities, while others limit themselves to observations of a purely meteorological character. Standard soot gauges have been installed by 11 authorities, though it should be explained that for the smaller authorities the cost of the analysis of the contents of the gauges is borne by the County Council. The information thus collected is forwarded each month to the Honorary Secretary.

Special Investigations.

In this connection several special investigations have been undertaken. One of these was concerned with carbon monoxide and its effect on the health of garage employees and of others exposed to this highly poisonous gas. Another was made into the presence of injurious metals such as lead, copper and arsenic in atmospheric dust. Specially prepared plates were exposed in Leeds, Huddersfield and Halifax under varying conditions and the dust deposited on the plates analysed by Mr. C. H. Manley, the Leeds City Analyst. The results though inconclusive were most interesting. It will be realized from these investigations that the Committee has not confined its attention to smoke only, but has included in its purview all impurities in the atmosphere.

Domestic Smoke.

With regard to domestic smoke, efforts have been made to interest the various housing authorities in the area in smoke reduction. In particular their attention has been drawn to the use of solid smokeless fuel for heating and cooking in the houses they are building in connection with their housing schemes. They have been exhorted to install grates capable of burning high temperature coke, which is more readily available than the low temperature variety and is no more expensive to burn than coal. At the same time a circular letter was addressed to all those authorities who possessed gas undertakings, asking them to increase their supplies of coke suitable for use in domestic grates and to facilitate delivery and storage by offering the coke to consumers in bags of convenient size and weight. The response to these representations on the whole has been satisfactory and to-day quite a number of housing authorities in the area have installed coke burning grates and are supplying specially graded coke for use in them.

Among the other activities of the Committee have been a special investigation into smoke and fumes from coke-oven plants and the nuisance arising from burning pit heaps. With regard to the former, the Committee visited a number of collieries in the vicinity and inspected their coke oven plants in operation. They

also went very fully into the design and construction of coking plants in general, with the object of suggesting improvements in the older and more obsolete plants from which the greatest nuisance arises.

Concerning the latter, a full report on the situation in the Yorkshire coalfield was considered and a letter was addressed to the Minister of Health informing him of the nature and extent of the nuisance and asking for wider powers than at present exist to deal with it.

The Committee has given prolonged and careful consideration to the thorny question of the establishment of statutory regional committees in the area, but has decided against the suggestion on the ground that control under a statutory body of this kind would be no more effective than under existing local legislative powers. One recommendation was made, however, and sent to the Minister of Health, and it was that sanitary inspectors whose duties include smoke inspection should be required to undergo special training and possess a certificate of competency in the subject.

The Yorkshire Regional Committee is a body of enthusiasts that takes its duties seriously. All the meetings are well attended and the agenda is never without some subject of local or general importance. If judged by the soot fall and daylight records the harvest has been meagre, there nevertheless stands to the credit of the Committee twelve years of useful work, the fruits of which will be seen in the coming years.

DISCUSSION.

Mr. James Law (Sheffield, Rotherham and District Smoke Abatement Committee) said that Dr. Burn had made some remarks and offered some criticism to the working of the Sheffield, Rotherham and District Smoke Abatement Committee, and the reply to that criticism would take the form of a number of questions which were as follows:—

Would Dr. Burn explain what kept nations and individuals from breaking laws? Was it not the fear of the consequences?

Was it not a fact that co-operation generally took place after the service of a statutory notice or the service of a summons?

Would he tell them what percentage of manufacturers would willingly co-operate and install expensive plant if they could not see a fair return for their capital expenditure?

Could Dr. Burn give them comparative figures of smoke emission from other towns in his area similar to those shown by Dr. Veitch Clark in his paper?

How was he to know what emissions took place in the districts where no systematic observations were carried out?

He stressed the application of Sheffield for the repeal of Section (1) (1) (e) of the 1926 Act. Was he aware that this exemption was provisional for five years, and was now very much overdue?

Did he persist in his statement that Sheffield was seeking fresh legislation, or would he agree that the application was being made for a provisional clause—which was a notoriously bad one—to be rescinded?

Was he aware that a “gentleman’s” agreement was made at that time to suspend prosecutions until some definite progress was made with regard to those processes?

Would he suggest that that agreement should be broken without first trying the orthodox method of arriving at an amicable solution?

Had Dr. Burn interested himself sufficiently to find the national opinion about this clause?

Was he aware that out of 28 local authorities interested 19 of them, including his own city, were in favour of its repeal, five were non-committal and the four negatives were only concerned with the depressed condition of trade?

Would Dr. Burn please repeat what he stated last year, “that the Midland Advisory Smoke Abatement Council was ‘dead but would not lie down,’” and would he give them his considered opinion why it had reached that moribund condition?

Was it not a fact that it was because the Advisory Smoke Abatement Council had no power, and was not a rational functioning body?

Mr. Thos. H. Ashford (Glasgow) said he had found the viewpoints as expressed by the various speakers on the above subject most interesting and informative, while the controversial aspects as regards statutory versus advisory committees demanded careful thought as he considered that the nature and extent of the main class of industry in any given area would have a definite bearing on the arguments put forth in support of either form of administration. In Scotland so far no form of regional administration existed because there was no uniform power of control, a circumstance which was still leading to many of the anomalous positions which had been experienced elsewhere. However, there was a definite move towards the seeking of general administrative powers which would lead to a common procedure in the application of such powers and also in methods of control. He was of the opinion that when regional areas are formed they would be of a statutory character.

He noted that in one of the papers the speaker stated that the manufacturer “if approached in an amicable spirit is always inclined to reciprocate with a desire to improve his plant and eliminate smoke nuisance.” He was afraid that had not always been his experience. While generally this statement was true with regard to large-scale undertakings, there were very many of the medium and smaller sized plants in which the management would only co-operate after coercive measures had been resorted to or after the threat of such action being taken was made following repeated warnings. It was an unfortunate fact, but there were

people so mentally constituted that where they consider the official had not adequate powers to enforce his request for improvement they simply "sat on the fence" and do little or nothing; and while it was also true that these cases were in the minority they were the cause of very many of the complaints handled. It was here that the statutory power would be effective. On the whole, of course, the smoke inspector's work was naturally of an advisory nature.

Another vexed question was that of the training and qualifications of the smoke inspectorate. On this subject at the London conference last year he was afraid he spoke at great length, and he did not intend to enlarge on it here, but would merely content himself with reiterating that for successful smoke abatement administration the sympathy, co-operation, and assistance of the plant owner and user must naturally be the desiderata and in order to attain this it was necessary that the utmost care should be taken not to insult the intelligence of such people by men being sent to guide and advise them on their own ground who were not by training and experience specially fitted for such work.

The educational aspect was one which has been referred to particularly in regard to the training of stokers, and he might say with all modesty that in the Glasgow area they had excelled for many years in that respect.

Mr. Geo. W. Farquharson (Birmingham) said it was evident by the paper read that afternoon that good work was being done by the Regional Committees, whether advisory or statutory. After all, they were all striving for the one end, i.e., Smoke Abatement, and by the use of propaganda, education and interchange of ideas, good seeds were sown towards this common cause.

As a smoke inspector, he would like to ask Mr. Law under which legal administration did he prefer to work, i.e., under the Public Health Acts or under private corporation Acts.

Dr. Johnstone Jervis stressed the need for good inspectors to carry out the specialized work. He would suggest that the Royal Sanitary Institute should stiffen the examinations, and tighten up the regulations for the Smoke Inspector's Certificate. Smoke abatement was an engineering problem and the inspector must have a good knowledge of engineering and combustion when dealing with the subject as part of his routine duties.

Mr. C. M. Opie (Liverpool) said that Advisory Regional Committees had a limited sphere of operations and in due course local authorities showed a lack of interest. All local authorities should make full use of their present powers and press for further authority. It was essential that the smoke problem should be considered more frequently and more seriously by those who serve upon the Councils, and smoke abatement looked upon as being one of the most important and necessary parts of public health administration. The chimneys of the various public institutions in many areas were among the worst offenders and local authorities should put their own house in order.

Mr. J. W. Beaumont (Halifax) said they had listened to six papers dealing with the work carried out by Regional Committees, and, as might

have been expected, they mostly dealt with the advantages or otherwise of Statutory Regional Committees.

The arguments put forward in favour of the establishment of such committees might be briefly stated as follows:—

(1) That smoke inspection was not properly carried out by many local authorities because they either would not or could not appoint specially qualified inspectors, where such were necessary, and that many existing sanitary inspectors possessed no special qualifications for this work, and in any case had so many other duties to carry out that they were unable to deal adequately with smoke inspection.

(2) That many local authorities did not exercise the statutory powers given them to deal with smoke nuisances because they were either indifferent to the matter or were overridden by vested interests.

It was at once admitted that many local authorities did not employ specially qualified inspectors where such were necessary for smoke inspection, in the same way that in many cases quite inadequate staffs of inspectors were employed for other purposes.

It was also admitted that there were many sanitary inspectors carrying out this work who possessed no special qualification for doing so. Realizing this fact the West Riding of Yorkshire Regional Smoke Abatement Committee had recently made a recommendation to the Minister of Health that sanitary inspectors whose duties included smoke inspection should be required to undergo special training and possess a certificate of competency in the subject.

This, however, did not mean that the only solution to the problem was the establishment of Statutory Committees. Referring to the last published annual report of the Sheffield, Rotherham and District Smoke Abatement Committee—the only Statutory Regional Committee in Great Britain—Mr. Beaumont called attention to the fact that there was a staff of four inspectors working under the supervision of a chief inspector, all of whom were engineers with special qualifications and experience in smoke abatement work. The area of the Committee covered about 123 square miles, and contained about 3,900 chimneys. As the area was divided into four districts it would appear that each of the four district inspectors was responsible for an area of more than 30 square miles and 975 chimneys. How could the work be properly carried out under such circumstances? As a hard worked sanitary inspector carrying out smoke abatement work in addition, Mr. Beaumont said his sympathies went out to these inspectors who were doing their best under such adverse conditions.

It would no doubt be pointed out that these chimneys were not evenly distributed throughout this large area and could therefore be more easily supervised than would at first appear to be possible. He would accept such a statement and supplement it by suggesting that probably 90% of the smoke produced in the area was produced within the boundaries of Sheffield and Rotherham whose representatives formed seven-tenths of the Committee. That being so, it established his argument that smoke was almost entirely produced within the area of large local authorities—

county and municipal boroughs—which could well afford to pay for the services of specialist smoke inspectors. We were often told that the work of smoke abatement carried out in such districts was to some extent negated by the smoke carried over from small surrounding districts, but was it not true to say that the smoke from the areas governed by the larger authorities did far more damage to the smaller areas?

As to the statement—often made—that many local authorities did not exercise their statutory powers, one might be justified in doubting the reliability of such a statement. For instance, the annual report already referred to, stated that although there were reported to the Committee 12 cases for prosecution, no legal proceedings were instituted. No doubt there were good reasons for this, although the same circumstances in connection with a local authority might not be interpreted in the same way. If such a statement was true, however, it was difficult to see how the mere formation of a Statutory Committee consisting of representatives of such authorities would effect a remedy.

All local authorities should be compelled to carry out their obligations in smoke inspection under present legislation, and provide adequate staffs for the purpose. Until this was done there would appear to be little hope of any improvement in the condition of the atmosphere in their industrial areas.

Mr. W. A. Damon (Chief Inspector of Alkali, etc., Works, Ministry of Health) said that if smoke control was to be successful it must be on a regional basis. The primary function of a Regional Committee should be preventive, and to exercise such functions properly the Committee must have at their disposal the services of expert smoke inspectors possessing working knowledge and experience of the installations they have to inspect. Dr. Jervis had very rightly called attention to this necessity and the West Riding Committee had recently forwarded a recommendation to the same effect to the Ministry of Health.

The duties of a smoke inspector should constitute a full-time job and should not be tacked on to an already overburdened sanitary inspector. A small local authority could scarcely afford a full-time inspector even if they had scope for him. Smoke inspectors should, therefore, be employed by the Regional Committee in sufficient number for the whole district to be adequately inspected. The Regional Committee would consider the inspectors' reports impartially and decide what action should be taken. Mr. Law had shown that such procedure was effective in eliminating the difficulty of vested interests.

A "Statutory" Committee was not different from an "Advisory" Committee except in the extent of the powers which the constituent authorities had delegated to it. Under present-day conditions, some such procedure was essential and it should cover all the industrial districts. He would like to see the London Committee revived and others formed in the Potteries and elsewhere.

Progress could only be obtained through co-operation of the Regional Committees with each other, with industry and with the Central Authority.

Mr. Matson (Hayes & Harlington) said he was from the south : sufficiently far south to know on arrival at Leeds that he was in the north ; and sufficiently far south for him not to be interested in whether Leeds was cleaner than Birmingham or Sheffield cleaner than Halifax. He had seen most of those towns for the first time and he thought they were all pretty bad. The fact that most of the delegates were from the north and Midlands seemed to confirm the view that smoke abatement was a northern problem ; such was, unfortunately, not true : the south was suffering from what had been referred to as the whimsicalities of managing directors' wives—they persuaded their husbands to come south and with their husbands they brought the smoke problem. Urban authorities around London were becoming alive to the fact that they were faced with the problem Leeds and other northern towns would have been faced with last century if there had been a smoke abatement society or even such a thing as smoke abatement : the problem of preventing factory smoke, or at any rate of minimizing its effect by careful planning, adequate plant supervision and furnace personnel education. The Regional Committee, if adapted to local conditions, seemed to him to provide the best method of securing for a district the services of the fuel specialists and qualified inspectors without whom the problem could never be tackled. The main difficulty in forming such a committee was the bugbear of amalgamation : most local authorities were so anxious to swallow some of a neighbouring area or so afraid of losing some of their own or even their autonomy as to be unwilling to co-operate with their neighbours in any matter. It was a difficulty which could, and he hoped with the help of the society would, be overcome. He sought information as to the existence of committees in similar areas to that he described, the number of shafts per man or other bases of work and for details of costs. He hoped to see a regional committee set up to include his district. He sought the experience of others in dealing with smoke, ash, etc., caused by firms burning waste materials on open fires screened by corrugated iron.

Mr. T. E. Birtwisle (Sanitary Inspectors' Association and Castleford) said that he did not think the mere setting up of statutory committees in place of advisory committees was going to bring about their salvation in the matter of smoke, and he wished in this connection to support the contention of Dr. Burn.

He remembered the setting up of the Sheffield and Rotherham Committee which took unto itself statutory powers and appointed its own officers, and was to make "the desert to blossom as the rose."

He had failed to see, however, any such blossoming as a result of the establishing of that committee. He instanced a chance observation which he had made when in the area a few months ago when a series of chimneys were seen to emit for fully 20 minutes dense black smoke in such quantity that one could believe the source to be the veritable fires of Tophet. Doubtless the cause was some steel manufacturing process, but such processes were only protected so far as smoke was necessary, and one

could not think that it was necessary to the process to discharge smoke to that extent.

The application for the exemption for such processes to be lifted was to some extent at least a confession of failure. He did not blame the officers of the committee; they were attempting the impossible. What could five smoke inspectors do with 123 square miles to cover?

With reference to what had been said about sanitary inspectors and smoke abatement, he would like to call the attention of the Conference to the large and growing number of sanitary inspectors who held the qualification in smoke inspection granted by the Royal Sanitary Institute. If that qualification were considered to be of no value then it ought to be scrapped and another examination set up.

He submitted that if there had been any failure on the part of sanitary inspectors in this work, it arose from the same cause as the failure in the area of the statutory committee, viz., that their numbers were insufficient.

Mr. James Law, replying to the discussion, said Mr. Beaumont stated that the number of inspectors was insufficient. The systematic observation of chimneys used to be carried out monthly, but with the increase of trade it had now been found possible to cover the area only once in six weeks, and it might be found necessary to increase the staff.

Mr. Birtwistle stated that he saw a chimney smoke for over 20 minutes without cessation. That was quite possible with a metallurgical process chimney at an early stage of the process, where coal was used as fuel.

Mr. Farquharson asked if it was better to take proceedings under a local Act or under a national Act, and, in replying, a question of Dr. Burn's could also be answered. Local Acts were much simpler in their method of procedure and the Birmingham Act did not exclude metallurgical process chimneys, so that Birmingham were in the fortunate position of being able to prosecute offenders without having to face the issues involved in Section (1) (1) (e) of the 1926 Act.

With regard to Dr. Burn's remarks about Executive Regional Committees, an appeal was made to all delegates not to take an *insular* view of smoke abatement. Because Birmingham did not suffer from other people's smoke on account of its geographical position, it did not follow that other districts do not suffer from Birmingham's pollution. "Smoke knows no boundaries" and it was important that a broad aspect of smoke abatement should be made in order to control pollution from every source in every district. Pollution and regional committee work in the North and Midlands had been discussed, but no mention had been made of what was taking place in the South of England. It would be comforting to think there was no smoke nuisance there, but pollution statistics which were published monthly did not give any indication that it was so. In the Metropolitan areas the records for high pollution readings at the early part of this year were somewhat surprising, one gauge reading January,

42.77 tons, February 54.55 tons, March 172.62 tons and April 69.47 tons, which showed twice the amount of the dirtiest gauge in Sheffield. Appreciation was given to Dr. Veitch Clark's well-considered reasoning on Regional Committee Control and it was hoped that that paper would be remembered by the delegates who were fortunate enough to be present when it was read.

Saturday Morning, 2nd October: 3rd Conference Session.

EDUCATION AND SMOKE ABATEMENT.

**Opening Remarks by the Chairman,
Professor J. W. COBB, C.B.E., B.Sc., F.I.C.**

Two sessions of this Ninth Annual Conference of the National Smoke Abatement Society have already been held and interesting matters have been discussed. This morning has been set aside for the more special consideration of the educational aspect of smoke abatement. A report will be presented by the Secretary, Mr. Marsh, on behalf of the Executive Committee, and that will deal with the desirability of bringing home to the rising generation, even at school age, the advantages that would come from a clean atmosphere, and imparting some knowledge as to how this reform could be secured. Additions to the school syllabus, which is already very full, have to be made with care and skill, and how they are to be made will be, I understand, the essence of Mr. Marsh's contribution. Such a proposal, however attractive, requires examination and discussion, and Dr. Mason is here from the Board of Education to state the case as it presents itself to one concerned with educational administration.

I may point out, however, that education on this subject may be taken as having a very wide meaning and application and there is more than one field in which its work may be done. It is true that the arousing of the public conscience to the harm done by smoke is a primary necessity, and it is perhaps in this direction that the National Smoke Abatement Society has done its most valuable work. Education helping to bring about the realization of how important this evil is deserves all the attention that can be given to it. There follows as a natural corollary education in the means which can be taken in practice for the elimination of the evil, and this is of different kinds and different grades. To begin with it should stress the existence and advantages of methods by which heating may be effected without the production of smoke, such as the use of coke, gas and electricity in the home. On the larger scale, too, in works, the same sort of improvement can be brought about, and education of workmen and those responsible for the management of technical processes is all part of the programme required. Much is already being done, as is plain, if one considers the process of steam raising, which is responsible for the consumption of so much fuel in this country. Education of one kind is giving a higher degree of skill to the men firing the boilers and education of another kind is making it possible to design and construct steam raising plant which is not only more efficient for its purpose, but is much better adapted to work without the emission of smoke. The advances, however, bring about their

own problems. The use of pulverized fuel instead of coal slack may substitute a dust nuisance for a smoke nuisance, and the great concentration of coal combustion in a small area such as we see in a great modern power house calls attention to the sulphur content of coal and the atmospheric pollution following its oxidation to sulphuric acid. This problem has already been attacked successfully in London and elsewhere by the methods of chemical engineering, and similar problems which will continue to arise will need the most scientific technical education in fuel technology which we can bring to bear. This is becoming increasingly recognized. One of my memories as a student is that of the late Professor Cohen, who did such valuable pioneering work, working enthusiastically at the University of Leeds on the systematic testing of the coal fire, and Professor Smithells studying the mode of combustion in the Bunsen burner. At the same University now is established an active department of Fuel Technology, working on the problems of the gas and allied industries and in the training of fuel technologists. Examples of the same developments must be multiplied. It is to education that we have to look all the time; education of different grades but all seeking the same end, the efficient utilization of fuel for the generation of heat, light and power with the very minimum of atmospheric pollution.

Report by the Secretary on behalf of the Executive Committee.

To achieve smoke abatement needs the creation of a public opinion aware of the harmful effects of smoke and anxious to co-operate in its prevention. We are still a long way from that position, in spite of the progress that has been made and is being made, and in many ways it is very difficult to bring about the necessary new outlook to those whose thoughts and habits have become stabilized. To some extent it is more promising to direct smoke abatement propaganda, especially if it can be intensified, towards those who are growing up and whose minds are more receptive to progressive ideas. Fortunately, the smoke abatement movement is not isolated, but is part of a much wider social movement that is seeking to bring about cleaner and seemlier towns and homes and to raise the amenities of life to a level more in keeping with what is known to be both possible and desirable. Fortunately, too, smoke abatement fits in with modern ideas of housekeeping: labour-saving, economical and efficient appliances, and absence of anything that means dirt and useless drudgery.

These trends, both social and concerned with the home, are of course part of the natural evolutionary change that is always in progress, and they are naturally accepted and considered to be more important by the young than by the middle-aged and old. What is wanted only by the enlightened of one generation is

demanding by the majority of the next generation, and what is at one time a distant ideal becomes a few years or decades later an urgent matter than can be and is brought into being.

Education in the schools can stimulate and to some extent help to direct this change by helping the child to understand, in broad outline, what is happening in the changing world in which he will soon have to play his part. On leaving school the youthful citizen should have at least an elementary understanding of what is being done, and what is being urged should be done, to improve the conditions and amenities of life. Questions of personal health and hygiene, town-planning and the preservation of the countryside, housing and similar social problems, are among the questions of which the young citizen should at least be aware.

The problem of the abatement of the smoke evil and the value of a clean atmosphere should be included, for it is a problem which touches the health and well-being of the individual, yet can be classed also as a social or civic reform, and depends for its solution largely upon the attitude of the householder and the housewife. Apart from our own direct interest in the matter it will be generally agreed that the subject is of sufficient public importance to warrant some knowledge by the children in the schools.

Ways and Means.

The need for the Society to take more active steps to ensure a due consideration of the subject in the schools has for some time been apparent, and the ways in which this could be done have been discussed at some length by members of the Executive Committee.

There is, to begin with, no desire on our part to try to put forward smoke abatement as a "subject" to be dealt with in a series of lessons. There are already enough "subjects," and too many people urging the claims of new ones, for this to be considered. It would not be fair to ask for this to be done, and it would be hopeless to expect it.

Alternatively, we might propose to the educational authorities that occasional special talks on the subject should be given, either by the teacher or headmistress or headmaster, or by outside people qualified to lecture on the subject. We understand that there are already more than enough individuals and associations clamouring for facilities for special lectures in the schools—which obviously can only rarely be arranged—and we feel that by adopting such a course we might easily lose more sympathy and interest than we should gain.

Special talks by teachers are more likely to be given, and perhaps to be listened to, and this might quite easily be done, where desired, if the scheme outlined below is adopted.

This is to propose, not that information on the smoke problem should be given apart from other subjects, but that the appropriate aspects of it should be dealt with where they naturally come in the normal courses in such subjects as Hygiene, Domestic Economy, and General or Elementary Science. For example, in lessons on hygiene, stress is laid on the value of fresh air and the healthy functioning of the respiratory system. It is only one small stage further for the teacher to point out the value not only of fresh, but of pure, air; and to explain how the health of the respiratory system is impaired by the continuous breathing of polluted air. Indeed, in this particular example, it is probable that in many cases something on these lines is already given. Elsewhere in the study of hygiene and health the opportunity occurs for the introduction of the relevant information regarding atmospheric pollution. The same thing occurs in the study of domestic economy, especially on the questions of cleanliness and economy in the home and heating systems, etc., and in many places in general science and such subjects as botany, natural physics and elementary applied science.

The Manchester Education Department have very kindly gone to the trouble of obtaining for us a general outline of schemes used in elementary schools in the area for the subjects mentioned. The actual syllabus used in different schools varies, and will naturally vary in other areas. But it may be taken that in general the children in the elementary schools receive instruction broadly on the lines indicated. The schemes are given below, and the items in them where smoke abatement or the question of atmospheric pollution can very properly be introduced have been italicized :—

Hygiene.

Simple physiology : study of bones, circulatory, *respiratory*; and digestive systems. Simple food values; clothing, comparison of suitable clothing fabrics, *ventilation in home and school*; *importance of fresh air*, posture : simple rules of health, *importance of cleanliness of the skin, of clothing, of houses, of foodstuffs.*

Domestic Science.

Twelve to fourteen lessons on housewifery dealing with *care and cleaning of all simple household apparatus and furnishings*; *cleaning and comparison of different types of kitchen ranges, stoves and gas and electric cookers, removal of loose dust and dirt, importance of proper ventilation*; *suitable domestic fuel.*

Twenty-eight to thirty lessons on laundrywork dealing with simple washing methods for different fabrics; a study of

the actions of cleaning materials on fabrics; care of laundry apparatus, planning and cost of household wash; removal of stains and general renovation of garments.

Seventy to eighty lessons dealing with choice, value preparation and cooking of foodstuffs; *care of cookery apparatus and stoves*; planning of menus and study of nutrition; relation between food and health; household budgeting, etc.

Six to eight weeks advanced housewifery dealing with *household routine and management*; choice of house with respect to site and building; *ventilation*, drainage and *hot water systems*; *rules of health*; household, laundrywork and cookery; infant welfare and first aid.

Science.

(a) *Heat; study of flame and products of combustion with reference to domestic fires, household stoves.* Effect of heat on solids, liquids and gases, with reference to simple household activities. *Conduction, convection, radiation, with reference to clothing, and to heating and ventilation of houses*

(b) Water. Hard and soft water. Sources of water; town water supply. Water as a cleaning agent. Water softeners, composition of soap.

(c) *The atmosphere. Weather conditions; air pressure and temperature; ventilation of buildings.*

(d) Foodstuffs. Action of heat on different foods with reference to suitable cooking methods. Tests for starch, protein, fats, mineral salts and water. Digestion and absorption of food.

(e) Source and structure of fabrics. Choice of suitable clothing fabrics in relation to health.

(f) *Electricity, its generation and distribution.* Construction and care of apparatus.

(g) Nature study (associated with gardening): Study of structure of plants, life cycle of plants; comparison of plants and animals. Plants as foodstuffs. *Study of soil and climatic conditions, growth of plants as associated with geographical conditions.*

In secondary schools the schemes used usually follow the lines of the school certificate or other examination syllabus, but here again similar opportunities will occur for bringing in appropriate smoke abatement matter.

The necessary information could be imparted to the children without undue trouble to the teachers and without in any way tending to overcrowd the lessons. Because of this we feel that

we can ask for the interest of the educational authorities and the individual teachers so that our proposals may be adopted.

For this to be done it will be necessary to supply to the teachers the necessary information. This need be given in a broad and general form only, and could conveniently be collated into small text-books or pamphlets. Three of these appear to be necessary—entitled, say, “Hygiene and the Atmosphere,” “Smoke and Domestic Economy,” and “Atmospheric Pollution in Relation to Science Teaching.” These booklets would be concise and practical and, it must be stressed, would be for the use of the teacher and not the pupil. Though short, they would be written as nearly as possible in the form of objective text-books, and care would be taken to prevent them having the flavour of propaganda publicataions. They could be considered, in fact, as appendices to the usual text-books on the subjects concerned. Their nature is indicated by the following outlines, although these must be considered only as provisional:—

“Hygiene and the Atmosphere.”

Introduction

Impurities in the atmosphere ; their sources and nature :—

Dust

Bacteria

Odours

Smoke

Carbon Dioxide

Carbon Monoxide

The obstruction of light by impurities

The effects of impurities upon health

Other deleterious effects upon general hygiene.

“Smoke and Domestic Economy.”

What smoke is

Domestic Fuels and Appliances

The effects upon domestic economy through:—

Increased labour or lowered standards

Domestic expenses

Personal—health, cleanliness, etc.

The responsibility of the individual household in reducing smoke by the utilization of smokeless methods.

“Atmospheric Pollution in Relation to Science Teaching.”

Introduction

Combustion

Fuels

The Atmosphere

Fogs

Impurities and their measurement
Outline of effects of pollution on everyday life.
Pollution and plant life.

The booklets would have to be distributed either through the local educational authorities or, with their consent, direct to the teachers concerned. Thus the approval and support of the educational authorities would first have to be obtained, and after that an interest and readiness to co-operate on the part of the teachers. The extent to which the information supplied would be utilized would depend, obviously, upon the teacher, and it is hoped there would be a willing response and a general desire to co-operate with the Society.

Included with the booklets would be particulars of charts and small posters which would be supplied, without cost, upon request. This material is not yet in being, but the subject is particularly suitable for illustration in a colourful and simple way. The use of these charts, in the right places, would give substance to the subject matter and be of direct assistance to the teacher.

In conclusion, the proposed scheme appears to be the one most likely to succeed and most likely to be used generally. It will, we hope, receive the approval and support that it requires. It may not, however, be in every way practicable or acceptable, and it is for that reason we are anxious to have the views of the representative of the Board of Education, who has accepted our invitation to attend the Conference to make a statement in the form of a short paper from the point of view of the educational authority.

Paper by Dr. F. A. MASON (Board of Education).

Like yourselves I have been listening with great interest to the speeches already made at this conference on Smoke Abatement and I have much pleasure in accepting on behalf of the Board of Education your kind invitation to make a short contribution to the subject in connection with education.

Before doing so, however, I am charged with a message to this meeting from Mr. Savage, the Senior Chief Inspector of the Board, to express to you the whole-hearted sympathy of himself and his colleagues with the aims and objects of the National Smoke Abatement Society, and to express his sincere regrets that he is himself unable to be present this morning as he would much have liked to be.

Now, Sir, I find myself today in the rather curious position of acting as counsel for the prosecution in a case where the defendant, though presumably—indeed, certainly—present in court, is so elusive that it is hardly feasible to confine him in the dock so that he mingles alike with judge, jury, and the public,

yet so serious are the crimes with which he is charged that neither witnesses nor counsel can be found willing to act for the defence, whilst the witnesses for the prosecution are as the sands of the sea shore.

It is true that I number amongst my friends some military and naval officers, a lawyer or two and—dare I suggest it?—a few politically-minded acquaintances, who are not unaware of the virtues of smoke clouds as a method of concealment.

Some of my artistic colleagues again will sometimes sing the praises of smoke—or as they term it *atmosphere*, for softening the harsh outlines of awkward and unpleasant corners which would be revealed by the too crude light of the sun.

I fear, however, that these lines of defence will be of little value in the present case and our main object will be to urge sentence of death and determine how best this penalty can be carried into effect.

Quite frankly, gentlemen, may I say here and now that I do not believe in smoke abatement?

What I do believe in is Smoke Abolition, and it can be done if we have sufficient force of public opinion behind us.

I suggest, sir, that it is about time that the name of the Society was changed from the National Smoke Abatement Society to the National Smoke Abolition Society.

Excessive smoke can and ought to be prevented and—speaking for the moment unofficially—I can not help feeling that some measure of compulsion will have to be adopted in the near future, otherwise we shall make but poor progress. A few years ago we were assured that it was dangerous and impracticable to drive without continuously sounding a motor horn; a law was passed prohibiting the sounding of motor horns after 11-30 p.m. and what is the result? Hardly a horn or siren sounded from day's end to day's end and no one a penny the worse.

We have compulsion in building laws which compel certain minimum requirements to be fulfilled in the matter of thickness of walls, drainage, window space and so on. Licences are demanded for owning and driving a motor car, and we have necessary and reasonable compulsion in a thousand and one other ways.

Why, then, should this universal and noxious problem of smoke and fumes not be tackled more drastically by advice and the threat of compulsion?

Now, from the educational standpoint, schools and other educational institutions can act both as contributors to and recipients of atmospheric pollution.

On the former topic we need not say very much: schools and technical institutions throughout the country are, of course, of all types and ages, old, middle-aged, young and, in many cases, are still in process of gestation.

The older types of schools, particularly smaller ones, were, and in many cases still are, heated by the picturesque but smoke-producing method of the open coal-fire.

Generally, however, the tendency today is to get right away from this and the modern type of school is warmed by the centralized method of hot-water pipes, gas-radiators, electric panels and similar methods that give rise to little or no smoke or fumes, so that although we have still some way to go in this direction, school authorities throughout the country are well aware of their responsibilities, and we may rest assured that the various agencies such as Public Health, Town Planning, and Architects' Departments will all pull their weight in seeing that educational buildings do not in any way increase the amount of smoke and dirt in the atmosphere.

So much, then, for that point.

The second point, however, is a much more serious one: schools—that is to say the children, the teachers and the actual buildings are all recipients in varying degrees of the unwelcome gifts of smoke and dirt which we seem to associate with modern industrial civilization.

From the administrative point of view it is convenient to divide the subject of education into three main groups.

- (i) *Elementary*, up to 14, or as it will be, 15 years.
- (ii) *Secondary*, from, say, 11 to 16 or 18, and
- (iii) *Further Education* after the boys and girls have left school and are going out into the world. This, of course, covers such phases as part-time day and evening classes in commerce, technology, domestic subjects in adult education in all its phases and, in fact, all these varied educational activities which our Elementary and Secondary colleagues kindly leave to the Technological branch!

To return now to the first category of juniors:—

1. *Elementary Education*. It has been pointed out by your Secretary that “what is wanted only by the enlightened of one generation is demanded by the majority of the next generation and what is at one time a distant ideal becomes later an urgent matter. Education in the schools can stimulate and help to direct the change by assisting the child to understand in broad outline what is happening in the changing world . . . the subject of the smoke evil is one which is of sufficient public importance to warrant some knowledge of it by the children in the schools.” With this I am sure we all agree.

Too many pupils and their parents unfortunately have first-hand knowledge of the subject of atmospheric pollution—there are still some schools in heavily industrialized areas where even

grass will not grow, schools where the windows can only be opened at intervals lest teachers and taught be choked with fumes and smoke—and children grow up all too familiar with dust, dirt, grit and soot which make the lives of the teachers and of the children's mothers a ceaseless and rather one-sided struggle for fresh air and cleanliness. Such things ought not to be in a community calling itself civilized.

Apart from the directly harmful effects upon the health of the pupils—a subject upon which I do not feel qualified to speak but upon which school Medical Officers can expatiate—there is the ever-present struggle to keep school premises clean and bright and fit habitations for our future citizens.

One method of dealing with the problem is to use dull brown and "sub-fusc" colours for paint-work in the hope that—as the saying goes—"the dirt won't show." That, however, is surely a counsel of despair and one can but appeal to school managers not to adopt this defeatist attitude, but to use bright, cheerful colours and see that all possible means are adopted to keep them bright and clean.

This, surely, is sound practice both from the psychological and health standpoints.

Undoubtedly what we have to do with the children is to make them "smoke-conscious"—conscious that there is still a sun shining in the heavens and that the veil of fog and murk that prevents them enjoying its welcome warmth and health-giving rays is not an act of nature but is man's own evil handiwork, and what man has done he can, in this case, eventually undo.

To many town-bred children, possibly to nearly all, the presence of smoke and grime is unfortunately accepted as being in the natural order of things and the absence of sunshine, green fields and fresh air come to be looked upon as normal and even desirable.

How then can we best arouse the growing consciousness of the child in this respect?

One method which has been suggested by your Secretary is to enlist the support and sympathy of the teachers themselves and to use their experience to inculcate in their pupils a hearty and healthy dislike of smoke and dirt.

To some extent, naturally, this is done at the present time and no opportunities are lost to teach the lessons of sunshine, fresh air and cleanliness, but such specialized information as that suggested by the Secretary in his Report would undoubtedly be of great value.

It might be suggested that the best plan of all would be to place a suitably illustrated pamphlet in the hands of every school child, but with an Elementary School population of about 5,000,000 financial considerations make this impracticable and

even if we consider only the boys and girls in the top forms, some half a million or so, the expense would still be very considerable.

We are driven back, therefore, to the rather more practicable method of providing the teachers, particularly those dealing with Science and Domestic Subjects, with ammunition in the form of posters, and short, *well-illustrated* pamphlets suggesting how the subject of smoke prevention can be introduced into the ordinary school lessons at suitable points without interfering unduly with the normal school curriculum.

Whether the suggested titles and subject matter are the most suitable is a matter for consideration, but it is important that plenty of visual illustrations be included : these "get across" far better than much preaching.

At all events whatever course is found acceptable I think I may say that the Board of Education will be quite prepared to consider favourably the introduction of some instruction on the smoke evil where it can suitably be done.

Another way in which the problem can also be tackled is this :—there is a growing tendency in many Elementary Schools to get away from the text-book complex and to encourage children to look up information for themselves.

If I may take as an example the case of Electricity : the plan is to ask each of the children to draft out a list of say ten questions on the subject which they feel they would like answers to ; these questions—and there may be a total of many hundreds—are collated by the teacher, a suitable number are selected and form the basis of the lessons for the ensuing term or year.

For example, in a typical case we have such questions as these :—

1. How do electric switches work?
2. How is electricity made?
3. What is in the electric bulb that makes a light?
4. How does electricity get to our homes?
5. Why is the wire in an electric fire coiled round?
6. How does an electric iron get hot?

All quite simple questions, but they mean something real to the inquirers.

In due course the teacher—and it calls for no little skill and ingenuity—gives his or her course of lessons based in part on these questions and invites the children to discover the details of the answers from suitable simple text-books, or works of reference.

At the end of the term or year the process is repeated and now note the results ! (The following are fresh questions raised by children in the same class :)

1. If the whole of the district's lights go out, is there something the matter at the power-station?

2. Why doesn't the Eureka wire melt when the two bare wires touch?
3. What is tungsten?
4. What does Watt mean in a 60 watt and 100 watt lamp?
5. What is a hydro-electric plant?
6. Wireless is connected with electricity, well, electricity will not jump through a great space of air, so how does wireless jump from one pylon to another?

These questions alone show the remarkable increase in knowledge and interest obtained by this method of approach via the initial content of the child's mind.

Why should we not then endeavour to gain the child's interest in smoke and the atmosphere in a similar way?

One set of questions I have seen includes the following items :—

1. How does coal burn?
2. Is smoke the same as cloud?
3. Why does smoke come out of the chimney?
4. Is smoke the same as steam?
5. Where does smoke come from?
6. How does a gas fire give its heat?
7. What are the white things in a gas fire?
8. How does a gas stove work?

and so on.

Obviously a series of lessons based upon some such questions would do much to arouse the children's awareness of the existence of preventable smoke and dirt, and illustrated pamphlets and posters such as have been suggested in the Secretary's report would without doubt be of considerable value.

Attention might also be given to the possibility of groups of senior pupils, when paying a visit to the local Technical College or Technical Institute, completing their tour of inspection of the buildings by listening to a lecture on smoke and its prevention given, let us say, by a member of the scientific staff.

As regards Secondary Schools, which cater for selected pupils of ages of about 11 to 16 or more, the position is not dissimilar so far as concerns junior pupils, and here also their interest can be aroused by introducing the subject into lessons on general science, biology and domestic science, whilst the attention of senior pupils may be called to the topic in connexion with their more formal studies of modern history, hygiene, chemistry, physics and the like. Here again the provision of suitable literature, copies of photographs of smoke-smitten areas (a sort of "rogues' gallery") for projection with the lantern or epidiascope, and, where a cine projector is installed, by showing suitable

films connected with smoke, fog and combustion, would all help the good cause.

The last group, Further Education, concerns itself with the education of ex-elementary and ex-secondary school pupils of all ages from 14 to 40 and beyond. Apart from non-vocational activities, most of the classes held are of a definitely vocational character, such as commerce in all its varied forms, engineering, chemistry, bakery, textiles, boot manufacture, domestic science subjects and so on, and it is not easy to suggest any one simple method of approach for all.

Here also, however, by enlisting the active sympathy of suitable teachers and placing in their hands suitable literature, much might be done.

One definite step in the right direction has been the provision of special courses for the training of Stokers and Boiler attendants, the West Riding being specially active in this direction.

It is to be feared, however, that such arrangements are at best only palliatives and not cures. We have in many cases to educate our masters to make them realize that in pouring forth smoke from factory chimneys they are in fact wasting their money and that by consulting fuel engineers and chemists it is possible not only to stop the smoke nuisance but also to save money for themselves; self-interest and altruism in this case coincide.

Above all we must realize that from the point of view of the man and woman in the street, the problem is mainly an economic and aesthetic one. By reducing the cost of heating by smokeless methods of domestic heating and at the same time increasing the attractiveness of the means of heating, we shall attract to our side many millions of those who otherwise may remain unwilling to co-operate or at best will be but apathetic.

DISCUSSION.

Mr. J. W. Beaumont (Halifax) said they had listened to an excellent paper by Mr. Marsh upon this subject and were delighted to learn that Dr. Mason, as the representative of the Board of Education, was not only in favour of the general principle that some form of education in smoke abatement matters might be given in schools, but had certain definite ideas of his own as to how this might be put into practice.

Yesterday they had been debating very controversial matters, but he ventured to suggest that this morning they would hear no dissentient voice on the subject under discussion.

All public health workers were accustomed to hearing references to what is termed "acquired immunity" in relation to disease, and our endeavour should be to impress upon the child-mind, whilst it was still receptive, the importance of an atmosphere free from smoke.

Mr. George W. Farquharson (Birmingham) said that the views put forward by their able Secretary, Mr. Arnold Marsh, together with the address by Dr. Mason, had, he was sure, given them excellent food for thought.

With regard to education in the schools, could not the B.B.C. be approached so that a series of talks on Smoke Abatement could be included in their series of school talks?

In Birmingham classes for stokers did not attract sufficient numbers to formulate a class. This year, however, the Public Health Classes Advisory Committee had arranged for a course to be held at the Technical College, the syllabus covering that required by the Royal Sanitary Institute for Smoke Inspector's Certificate. The syllabus being elastic enough to take in classes for stokers and boilerhouse management, it was hoped to increase the number of students, and they had already a matter of 30 names put forward as prospective students for this course.

Mr. C. M. Opie (Liverpool) congratulated the Executive Committee of the Society on giving a constructive lead regarding education in schools on the subject of smoke abatement. The fundamental principles had been incorporated with existing subjects so as to make the whole matter a feasible proposition.

Children should be taught to regard coal as a raw material and not a finished product.

In regard to the classes that had been instituted at various centres to train engineers, firemen and others in the correct use of coal and the principles of smoke abatement, local authorities should encourage their own employees to attend and qualify at these classes. If the condition of appointment and promotion for boiler-plant attendants in the employ of local authorities depended on their holding, or, in due course obtaining, a qualifying certificate, a lead would be given to all industrial coal consumers.

Mr. A. Pickston said that to a professional teacher the temptation to use his special privileges in the service of a social movement must be well-nigh irresistible. Yet the conditions were rigidly defined. The movement must be non-political and the material it employed must be of value to the general development of the child or student.

He suggested that in the question of Smoke Abatement the conditions were satisfied perfectly. The evil of smoke was nearly impartial in its ravages—and its continuance was due to ignorance and indifference. If they, as teachers, could reduce in some measure the chief factor in the problem they would not have wasted their time.

There remained the problem of adding to an already crowded curriculum a sufficient and practical treatment of the subject. He was prepared to suggest that the problem was not a very difficult one. The responsibility for its solution lay chiefly in the hands of two teachers—the science teacher and the domestic science teacher. He was not qualified to speak for his colleagues on the domestic side—but he would like to think that they were all working *consciously* for smoke abatement. He could only express an opinion covering the other field of school science.

There was no doubt that the best method of approach, and one which was incidentally of great educational value, was the simple discussion and study of the nature of fuel, and the requirements for complete combustion. The properties of the air, and the process of burning already formed a considerable part of the most elementary science course. It was absurd that in many cases the next step was not taken—the application of those simple notions to daily life. In his view, the time spent in discussing fuels and their treatment, with the logical sequel of a clear understanding of the reasons for smoke, would be well repaid. The subject formed one of the neatest demonstrations of applied science in the province open to the teacher: it offered scope for many simple and interesting experiments in which elaborate apparatus was not required, and it had a large measure of correlation with other topics.

Councillor Mrs. Barnes (West Ham) said that her authority had done something in the schools so far as smoke abatement was concerned. They had set up small flats in connection with the schools, and these were all furnished with electrical apparatus. There were no coal fires, and this had been done to eliminate the smoke and dirt and so forth that occurred when coal was used.

She felt she ought to know about the technical side and had asked one of the inspectors to take her round some of the factories in their small industrial area. She was taken into a large boiler house and came to the conclusion that rightly managed and with the right type of trained man looking after the boilers and engines there would be no need for the Society.

The Society had got to get the women on its side, and it would be useful if there were more women sanitary inspectors. There were three in West Ham, and they were doing very good work.

Mrs. Barnes concluded by hoping that electricity could be made cheaper and its output increased, so that it might be more universally used.

Dr. Des Voeux, referring to the previous speaker's remarks, said that women should be more interested, but they were not. When the Coal Smoke Abatement Society started he expected great support from the women of London, but actually out of 150 members only four were women.

Alderman Shimmin (Leyton) said that he wished to oppose the report. He contended that many of the suggestions made were already embodied in the curricula of schools, at any rate in Leyton and West Ham.

Education authorities and the teachers were doing good work in that direction and it might be left to them. That Conference, however, was hardly the body to deal with education in the schools. As a member of a Public Health Committee he was prepared to take the advice of the Sanitary Inspector, but as a member of an Educational Committee, and as one who had over thirty years' experience as a teacher in elementary and secondary schools, he was not prepared to take the advice of the Sanitary Inspector or the Inspector of Mines in respect to Education.

The teachers had apparently not been consulted in the matter. He agreed that consultations between teachers and the Society would be of

value, but he opposed the report because the expense involved could be better incurred in propaganda in other directions.

His Borough Council had spent about 45 minutes recently discussing whether membership of the Smoke Abatement Society should be retained and it was decided in the affirmative, by a vote of 19 to 17 only.

There was much ignorance in respect to the smoke problem and something should be done to make people smoke conscious; it was being suggested that the progress made in arousing the adult mind was much too slow and therefore an attempt should be made to influence the children in the schools.

Much of the discussion at the Conference had dealt with matters relating to the North and Midlands. In his district it was argued, by responsible people, that the smoke problem was not important—and the solution wherewith to make the apathetic smoke conscious was to wait several years until the present generation had been influenced in the right direction by the lessons received in school.

There was a more effective way. There was machinery at hand which could be used; there were thousands of organizations throughout the country which met periodically, sometimes weekly, to discuss various social subjects including questions relating to health. It might be advisable to form an Education Department of the Society to deal with the question, but it should be possible to secure speakers in different districts who would be prepared to give their services voluntarily in order to address Women's Co-operative Guilds, Trade Unions, Ratepayers' Associations and other bodies—and especially women's organizations—on the various aspects of the smoke problem.

Local authorities were important but the groups which were concerned in selecting and nominating candidates for municipal elections were able to influence their nominees when they became Town Councillors. It should be possible to secure capable speakers who could put the Society's point of view before the members of such groups and possibly secure their support before discussion took place in the local authorities council chambers.

He submitted that propaganda such as that outlined would assist in the endeavour to make people smoke conscious.

Mrs. Renton Taylor (Chairman of the Leeds Branch of the Electrical Association for Women), deputising for Miss Caroline Haslett, of London, said that she wished to support Councillor Shimmin in his statement, that for the success of the Society it was necessary to get among the women, the domestic users of coal, and convert them.

Mrs. Taylor said she had been working among women's institutes and the Electrical Association for Women for eight years, yet had not come in contact with any person actively proclaiming smoke abatement, nor had she received any literature dealing with it, yet the subject was one in which the women's societies were very interested and she was glad that she had been able to attend the Conference because now she would do her best to get smoke abatement stressed as one of their aims, and so

get the subject publicly discussed and, she hoped, some useful local propaganda done.

Dr. E. L. Hummel (Board of Education) said that smoke-producing coal was used at the cost of men's suffering and lives. It was a crime to burn it for heat alone : as much a crime to burn raw coal for heat as it was for the early robbers of the Egyptian tombs to burn the finely decorated sarcophagi to boil water. Nevertheless, coal could be burned raw, and he instanced his experience of the Rand Power Station. He suggested that the Society should get furnace engineers and designers to influence industrial furnace design.

The household problem was a very difficult one, and people wanted the coal fire as an incinerator as well as for heating and cooking. Women especially were against any substitute for the domestic coal fire, and in that respect he would like to ask how many of those present had abolished the coal fire from their own homes?

Dr. Hummel continued by saying that there were many fine new buildings in Leeds, but even the new Queen's Hotel would in the course of time become as black as the Town Hall. Raw coal should be barred by law, as it was in the early days of the burning of "sea coal." The present fire place had developed from the wood-burning furnace and should be altered. He concluded by saying that the Board of Education would do everything possible to help the movement.

Mr. C. S. Shapley (British Commercial Gas Association and Inst. Gas Engineers) said that the Chairman had pointed out that it was education they were discussing and he thought they ought to start by educating the Press that Smoke Abatement was news for 365 days of the year and not just for the period of the Conference.

A subsequent speaker mentioned that they were not doing sufficient to educate the ladies. He saw Mr. Currier of Bradford there and he wanted to pay testimony to the work they are doing in Bradford and other cities in connection with the Women's Gas Council.

Having educated the Press they ought to start with the E.D.A. (laughter) and the B.C.G.A. (cries of Hear! Hear!), as he did not think that either of these bodies adequately supported the movement.

They should continue the education with councillors and aldermen and members of local authorities and also their officials.

Lastly, if it was possible, they should attempt to educate Members of Parliament as to the importance of clean air, but he very much doubted whether this was possible, as he did not consider any political party dared do what they in their own minds know they should do, i.e., abolish the use of raw coal.

Mr. Geo. E. Currier (Bradford Gas Department) said he thought they were all agreed that the Society had done and was doing much good work in the cause of smoke abatement. He also thought they would all agree that the present rate of progress was far too slow. Generally speaking the public was not smoke conscious, and that applied more in the North and Midlands than in the South,

Mention had been made of pamphlets as a means of propaganda among school children, but he thought the spoken word of the teacher had a much more lasting impression on the mind of the child.

The more difficult problem was to educate the present generation who were responsible for the use of fuel in the domestic and industrial fields. With respect to the former a suggestion had been made that the women had to be won over to the use of smokeless fuel and much useful work could be done by lectures to women's societies. It must be remembered that it was not always the poorer classes who burned raw coal in their houses—often it was found that it was the richer classes that were so strongly wedded to raw coal for house heating purposes.

The name coke used to be taken as an indication of second-class fuel but to-day this was not the case. In Bradford gas coke was specially prepared and graded for domestic and industrial purposes and it was always spoken of and sold as "Bradford Smokeless Fuel."

A lady councillor for West Ham had informed them of the contribution that authority was making to the cause of smoke abatement by the provision of all-electric flats for the education of school children. Up to a point that was quite good, but in common fairness that authority should also educate the children in the use of *all* smokeless fuels, including gas and coke.

Another speaker mentioned the difficulty of disposal of certain refuse in the absence of a solid fuel fire. That could be done quite easily by means of a gas incinerator.

It must be remembered that the gas industry provided both gas and coke as smokeless fuels and it had been proved conclusively that working-class houses could be run economically with a coke fire in the living room and with gas fires in other rooms, and in addition gas for lighting, cooking and hot water. With other smokeless fuel this was not an economic proposition, with the result that raw coal was burned in the living room.

Also the burning of raw coal in the industrial field was a very serious matter. Some improvement had been made in reducing smoke emission from chimneys, but the destruction of the most valuable of our national resources by the burning of raw coal continued to an alarming extent and it appeared that legislation would be necessary to restrict the use of coal in that way. The gas and coke oven industries recovered all the valuable by-products besides gas and coke, so much so that 80% of the heat energy in coal was recovered in the various products, whereas other industries allowed these by-products to go to waste up the chimney and to pollute the atmosphere.

The point made by Dr. Mason that it would be better if the word abolition was used instead of abatement was a very good one and he hoped the Executive Committee would seriously consider a change of name of the Society to "The National Smoke Abolition Society."

The Society deserved and should get more adequate financial support from all those who are interested in its objects in order that the scheme for the education of children and others should go forward without hindrance.

PUBLICATIONS of the NATIONAL SMOKE ABATEMENT SOCIETY

(All prices include postage. Reduced prices for quantities.)

RECENT PUBLICATIONS.

The Case Against Smoke. A new booklet which is intended to give the reader a clear understanding of the nature and extent of the smoke nuisance by means of passages from a number of writers and speakers, each of whom may be regarded as an authority in his own sphere. There are also figures and extracts from official reports and tables. Invaluable for those who write and speak on the subject. 24 pages. 4to. Price 3d.

Proceedings of the Science Museum Conference (1936). The most complete review of the problem to be published for many years. Twelve papers and discussions in full.

Technical: Methods for the Prevention of Grit and Dust Emission, by A. T. Barber and T. F. Hurley (Fuel Research Station); Smoke Prevention in the Iron and Steel Industry, by H. C. Armstrong; Smoke Emission in the Clay Industries, by E. Rowden and A. T. Green (British Refractories Research Association).

General: Solution of the Domestic Problem, by Dr. M. Fishenden; Through a Glass Darkly, by Noel Carrington; Effect of Pollution on Vegetation, by Sir Arthur Hill and Dr. C. R. Metcalfe (Kew Gardens); Developments in the Investigation of Pollution, by Dr. J. S. Owens.

Health: Pollution in Relation to Tuberculosis, by Sir Pendrill Varrier-Jones; Light and Clean Air in Relation to Surgical Tuberculosis, by Sir Henry Gauvain; Obstruction of Light by Smoke and its Effect on Health, by Sir Leonard Hill.

Administration: Public Health Administration and Smoke Abatement, by Dr. A. S. M. Macgregor (M.O.H., Glasgow); Smoke and the Sanitary Inspector, by H. G. Clinch (C.S.I., West Ham).

112 pages, 4to. Price 2/-. Limited quantity only available.

Handbook and Guide to the Science Museum Exhibition. The Handbook is not only a detailed guide to the Exhibition, but containing a series of twelve authoritative articles on the main aspects of the problem, is a permanent and useful reference book. There is a foreword by the Minister of Health, and in addition there is a series of communications from correspondents abroad on progress being made in other countries. 80 pages. Medium 8vo. Price 6d.

The Journal of the N.S.A.S. The Journal is not a record of proceedings but a magazine—the only one in the world—devoted to the problems of atmospheric pollution. Contains authoritative articles, notes on technical subjects, news of activities of every kind, and in general keeps the reader up-to-date in every aspect of the subject. Per annum, 2/6. Gratis to members.

Fumifugium; or the smoake of London Dissipated, by John Evelyn. This rare and fascinating book, first published in 1661 by command of Charles II., has been republished by the Society with an introduction by Miss Rose Macaulay. In spite of its age this indictment of the smoke evil by the author of the famous Diaries remains true, witty, and penetrating. Illustrated with original wood engravings and a portrait of Evelyn. Paper covers, 6d. Cloth-bound, 1/6.

Smoke and Fumes Nuisances from Road Vehicles. The technical and scientific aspects by Dr. J. S. Owens, A.M.Inst.C.E., M.I.Mech.E., and the legal position by R. P. Mahaffy, M.A. 8vo. pp. 16. 3d.

Smoke and Health by Dr. J. S. Taylor, M.D., D.P.H., Assistant Medical Officer of Health, Manchester. 8vo. pp. 12. 2d.

Smoke and Aviation. Full Report of the 1935 Conference on this subject. Four papers in full and discussions. "Smoke and Visibility" by C. S. Durst, B.A., Assistant Superintendent. Meteorological Office, the Air Ministry. "The Effects of Smoke upon Flying Conditions" by William Courtenay. "The Effects of Smoke upon Flying in the North" by Alan Goodfellow. "Visibility and Smoke in Relation to Aerial Photography" by Captain Alfred G. Buckham, F.R.P.S. With photographic illustrations. 8vo. pp. 40. 1/-.

Smokeless Open-Grate Fuels. Report of the Symposium held in 1934. Papers and discussions on all types of solid fuels, their uses and requirements by E. K. Regan, E. W. L. Nicol, Col. W. A. Bristow, H. Cerckel, Mrs. G. H. Miles, Dr. G. E. Foxwell, John Roberts, and Dr. E. W. Smith. 8vo. pp. 60. 1/-.

The State of the Atmosphere. "An Examination into the Effects of Atmospheric Pollution on Building Stones, etc., with a Preliminary Summary of the Conditions Disclosed by various Enquiries into the State of the Atmospheres of Great Britain," by Sir Frank Baines, K.C.V.O., C.B.E., F.R.I.B.A. An invaluable survey of the subject. Royal 8vo. pp. 36. 6d.

Home Fires Without Smoke. Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. Cloth-bound remainders, 6d.

The Smokeless Home. A popular 12-page illustrated pamphlet, with cover in colours, describing the ways and means for making the home smokeless. To be sold in quantities for general distribution. Single copies gratis. £5 per 1,000.

"Smoke Abatement and Fuel Economy in Steam Boiler Practice" (Published by the Manchester and District Regional Smoke Abatement Committee). pp. 11. 1d., post 2d.

N.S.A.S. Annual Reports. Gratis, by Post 1d.

PROCEEDINGS OF THE ANNUAL CONFERENCES.

Each with all papers in full, and discussions. 8vo. Price 1/- each.

Newcastle, 1932. Presidential Address and papers on: "The Domestic Smoke Problem: the Possibilities of Coke-Oven Fuel"; "The Psychological Effects of Smoke"; "The Human Element: A Factor in Smoke Abatement."

Glasgow, 1934. Presidential Address and Resolutions, and papers on: "The Measurement of Atmospheric Pollution"; "The Effects of Smoke upon Visibility and Aviation"; "The Effects of a Smoke-Laden Atmosphere on Horticulture"; "Nature in Beautiful"; "Slum Clearance and the Smoke Problem."
1933 and 1935—out of print.

In Course of Preparation.

The Law of Smoke Nuisances

Being "The Law Relating to Smoke
and Noxious Fumes" by the late
RANDOLPH A. GLEN, M.A., LL.B.,
extended and revised in accordance
with the Public Health Act, 1936,

BY

W. R. HORNBY STEER, M.A., LL.B.

RECORDER OF SOUTH MOLTON

(Standing Counsel to the Society)

To be published early in 1938 at 1/- each, post free.

Special prices for quantities.

Orders placed prior to publication will be appreciated.

**NATIONAL
SMOKE ABATEMENT
SOCIETY**



**Proceedings
of the
Cardiff Conference
1938**

**Price :
ONE SHILLING**

**Chandos House
Buckingham Gate
London, S.W.1.**

PROCEEDINGS

of the

TENTH ANNUAL CONFERENCE

of the

National Smoke Abatement Society

held at **CARDIFF**

2nd and 3rd DECEMBER, 1938

CONTENTS.

Presidential Address by Dr. H. A. Des Voeux	3
FIRST SESSION : THE DUTIES AND OPPORTUNITIES OF LOCAL AUTHORITIES.	
Chairman's Remarks, by Councillor James Griffiths ...	9
"The Administration of the Law and Co-operation with Manufacturers," by Dr. J. Greenwood Wilson ...	9
"The Training of Stokers," by S. N. Duguid	15
SECOND SESSION : "HOW SOUTH WALES IS ASSISTING SMOKE-ABATEMENT."	
Chairman's Remarks, by Professor R. M. F. Picken ...	31
"Welsh Smokeless Coals," by Thomas Dixon	32
"Gas in South Wales," by W. Clark Jackson	38
"Electricity in South Wales," by James F. Smith	46
"Low Temperature Carbonisation in South Wales," by Col. W. A. Bristow	53
ANNUAL MEETING : DISCUSSION AND RESOLUTION ON BURNING SPOILBANKS	
Others Resolutions passed at the Conference	74
Publications of the Society	75

Opinions expressed in conference papers and discussions are not necessarily the same as the official views of the Society.

PRESIDENTIAL ADDRESS

By H. A. DES VOEUX, M.D.

PROLOGUE.

*A mighty mass of brick, and smoke, and shipping,
Dirty and dusky, but as wide as eye
Could reach, with here and there a sail just skipping
In sight, then lost amidst the forestry
Of masts; a wilderness of steeples peeping
On tiptoe through their sea-coal canopy;
A high, dun cupola, like a fools-cap crown
On a fool's head—and there is London Town!*

—Don Juan, Byron.

The main occupation of uncivilized man, says a French psychologist, is to discover what enemy has bewildered him. We who count ourselves civilized, have been, and are being bewitched, and consequently injured, and in many ways deteriorated by modern discoveries. This is because our objectives have been blurred by the almost delirious excitement of the rapid control which has been gained over Nature and its forces. We can see this point of view almost daily, for there is no new invention or discovery which is not capable and has not been converted into a means of creating evil. For instance there has been much discussion lately over the fearful cruelty and destruction caused by aeroplanes, when used for purposes which did not enter into their original conception.

More than two thousand years ago, men conceived the idea that life in towns was the highest form of life, and that idea has developed into a realism in its extreme form, and in our large cities into a horrid and foul reality of dirt and sunlessness. The growth of towns did not seem to develop in the minds of those who lived in them the necessity for any change in their manner of living, and it was not for many hundreds of years that there seemed to arise a civic feeling such as we now know,

Towns were built at first for those whose intellect required communication with others; the life of isolation was, and is now, boring to those who require friendly conversation and intellectual stimulation. The towns also became centres of safety against enemies and unfriendly tribes, and walls became a necessity as they grew larger and richer.

The necessary restriction of space produced overcrowding which led to epidemics and frequent illness which there were little or no means of combating. With no good water supply, and no means of disposing of filth, is it to be wondered that the mortality was heavy?

There were a few exceptions to this rule of neglect, especially in Rome and a few Roman cities, and we are left in wonderment at the example which both Athens and Rome left us in unsurpassed examples of architecture, and the latter in its wonderful water supply and baths, while allowing slums to accumulate.

The disappearance of any ideal conception of a town during the Middle Ages, until the Renaissance revived interest, is remarkable. The mediaeval town was still half countrified, except in great merchant cities like Venice and the Hansa towns where a civic organization was created. There was little sign of a guiding principle, for towns were small though important, and problems of insufficient light and air were not vital.

Certainly the laxity of control allowed a picturesque variety of towns which grew up around a castle, cathedral, or even round a market, for food supply was a consideration where war was frequent.

The growing consciousness of something wrong in the way in which towns had been allowed to grow up, and their liability to periodical visitations of plague was reflected in various Acts, inoperative though they were. One of Elizabeth's reign stated "that no person shall build or erect any manner of cottage or convert any to be used as a cottage for living in unless four acres of land at the least be attached, under penalty of forfeiting £10 or £4 a month for every month it is upheld."

Again—"Great mischiefs do daily grow and increase by reason of the pestering of houses with divers families harbouring of inmates and converting great houses into tenements or dwellings, and erecting new buildings within the cities of London and Westminster whereby great infection of sickness and dearth of victuals and fuel hath grown and ensued."

I have seen this type of converted house in the city of Westminster, about forty years ago. There were many rooms in Westminster occupied by eight or nine people, but thirteen was exceptional, and we were begged not to knock them down because there was nowhere else for the people to go.

So it is evident that the question of overcrowding and uncontrolled speculation were as rife in Elizabeth's reign as in our own time, but with ineffective means of dealing with them.

These decrees were of little avail, and increase in commerce and prosperity brought in its wake the filth that made London an easy victim to the Plague, in spite of examples abroad, where a great commercial city could rival London in the amount of its commerce and far surpass it in cleanliness. For example, James Howell (a native of Brecknock) went abroad in Charles I's reign and found the people of Amsterdam "very neat, though not so magnificent in their buildings, and for cleanliness they may serve as a pattern to all people. They will presently dress half-a-dozen dishes of meat without any noise or show at all, for if one goes to the kitchen there will be scarce appearance of anything, but a few pots upon a turf fire which is their prime fuel. After dinner they fall ascouring of these pots so that the outside will be as bright as the inside, and the kitchen suddenly so clean as if no meat had been dressed there for a month before." And then he reports—"Paris on the other hand is always dirty, and 'tis such dirt that by perpetual motion is beaten into such a thick black unctious oil that where it sticks no art can wash it off; insomuch that it may be no improper comparison to say that an ill name is like the crotte (dirt) of Paris, which is indelible."

As for London, down the middle of the eighteenth century when each householder was relieved of the responsibility for his own filth, it proclaimed itself to Mr. Gilpin in his *Guide* of 1772 "with all those disgusting ideas with which its great avenues abound—brick kilns, heaps of collected soil and stinks of every denomination, clouds of dust rising from agitated wheels, villages with rural ideas, trees and hedge-rows without a tinge of green."

It is difficult to put a date on the commencement of the industrial era in England, but certainly it seemed to show signs of existence in the time of Bacon who speaks of the machines taking charge and drawing men from the country to work them, and creating not one Great Wen, but several.

"Whizz! Whizz! All by wheels! Whirr! Whirr! All by steam!" Kingslake's "Eastern Pasha" put in a nutshell the period of industrial activity which created the problem with which we are now faced, of mastering the demon that has bewitched us and turned us into barbarians. The savage regards our towns with horrified awe. So ought we, and some few do.

Smoke is one of its by-products. Smoke, in ancient times the medium of divine prophecies, of oracular declarations and in the middle ages of witches' visions. To-day it is the sign of ignorant wastefulness. The high function of smoke has

degenerated since the time when it elicited the presence of God himself.

When Mr. Gilpin expressed his abhorrence of the approach to London, he was merely expressing the growing feeling that the town was an excrescence, and not a place for civilized people.

This opinion is held by many, and it is in complete opposition to that held by the Greeks, who thought that it was only in towns that civilized people could live. People like the Macedonians were barbarians. But it is through modern misconception of the function of towns that they have in many of our manufacturing towns become such places of abomination. If modern man had modelled his centres upon some of those which have been in existence for many centuries—as example our Cathedral cities, they never could have allowed the present horrors to come into being. Smoke is only one of these horrors, but it is the one with which we are concerned, and if it were abolished we should approach from one angle the conception of the town where life might not merely be tolerable, but to some people of intense social tastes, agreeable.

We need not perhaps employ such vigorous measures as the execution in 1306 of the man who was convicted of burning sea coal and who perished, unwept, unhonoured, and unsung but who was the pioneer of smoky London. If South Wales had then properly stirred into life, and had employed the “push” of today, it would have supplanted the Newcastle coal, and as a consequence averted the dreadful catastrophe from poor John Smith.

Nevertheless, to us it seems reasonable that the smoke nuisance should be done away with, and some eighteenth century writers numbered smoke and tea amongst the causes of the increased number of suicides in London. But there can be no denying that smoke in some places has a charm quite its own. Who has not observed with pleasure on a fine but chilly autumn evening such a film of haze rising from a village in a valley! What does the expression—“Auld Reekie” mean to your mind even to-day! Some smokes even raise a romantic sensation in poetical and artistic minds. In a journal recently, a writer said he would hate to see the smoke of trains disappear, but I can only think that he lived in some country district and never put his nose into, or allowed his eyes to see our big railway termini and their blackened surroundings. Is it possible that when our object of clean towns comes to a reality such people will create a Smoke Preservation Society?

There is no reason why a great industrial centre should not be free from the evils of smoke. One need only compare the condition of the Civic Centre in Cardiff with the Town Hall in say Manchester to see that no industrial town need go black if

the right kind of fuel is used, and if towns are so planned that smoke is no longer a corollary of the town, then we may begin to look on towns once more as places to live in.

I have referred to the mediaeval towns which within their walls were laid out so as to be self-sufficient in war time. One might base on that a theory for our modern towns. One remembers Aristotle's description of the city state as of people living together in organized community partly for convenience, and partly to live in the fullest way possible. The dirt of industrialism has now made the town a place to escape from. Men live more and more in such towns to earn the competence which will enable them to escape. But this is a very futile ambition. Towns should be able to provide all the necessary amenities for the "good life" of the Greeks and make the agonized exodus that marks the week-end and turns roads into caterpillar extensions of towns, unnecessary.

Towns which have grown up as they have done in the last hundred and fifty years have become places to shun. Sanitary services may be better organized, but the smoke that befouls the air, the discharges from exhausts that sicken the stomach, the unceasing din that shatters the ear drums have made them places where life in the Greek sense is impossible. Those people who are fortunate enough to have ample leisure spend it in the country, and the town dweller is perforce an escapist. If our civilization is an escapist one, it is because the prospect of combining the healthy town in the physical sense with the healthy town in the spiritual sense has been lost sight of.

The abhorrence of the town which characterised the romanticists of the early nineteenth century has become a kind of obsession, which can be understood but which is an evasion of the fundamental problem.

Towns are still places which must be lived in, and if our civilization is to be an urban one, then its difficulties should be faced. The abolition of the smoke nuisance is not the least of these.

Not only in the physical, but also a psychological sense has smoke obscured the issue which we are hoping to solve, that is the, at present, unfulfilled problem of man's betterment. Our tendency is still to perceive and approve of the better course and to follow the worse one, to bear those ills we have, rather than to eradicate them. But the clean town is a conception that is so clearly realizable, and one to which the forces that created Coketown (Dickens) with its rubbish heaps and gloom might be harnessed, that we ought to spare no effort to gain their support instead of their opposition. The problem should never have arisen, but it is the face of each generation to spend a great part

of its energy in undoing the consequences of the mistakes of the last, and at least by doing away with smoke we can be relatively certain that future generations will not attack us for leaving them with such an abuse to rectify, though they may collect pokers and tongs with the same zeal with which we collect warming pans.

About one hundred years ago, a headmaster of Eton—Dr. Keates—when speaking to his pupils remarked: “Boys, you must be pure in heart, for if not I will thrash you until you are!”

Could this be applied to some recalcitrant Civic Authorities?

Friday Morning, 2nd December: 1st Conference Session.

THE DUTIES AND OPPORTUNITIES OF LOCAL AUTHORITIES.

**Opening Remarks by the Chairman, Councillor James Griffiths
(Chairman of the Public Health Committee, Cardiff City Council).**

It is a pleasure to be the Chairman of the first session of this great conference, and to welcome so many delegates from all over the British Isles to our beautiful city of Cardiff—one of the cleanest and brightest in the land, as I told you at Leeds last year; but I am afraid that some of you did not quite believe me then. Now that you have seen for yourselves, you will agree that it is even better than painted it.

The time has now come when all Public Authorities should put into operation the laws that will help to reduce smoke pollution to a minimum. In every large town and city one sees chimneys and stacks pouring out smoke. What a waste is this from the economic point of view, filling the air with fumes and grit, penetrating into thousands of homes, destroying curtains and furniture, making needless work for the housewife, turning everything dark and drab, polluting the air, and no doubt causing ill-health amongst the community. It is almost impossible to estimate the financial and physical loss caused by smoke and fumes polluting the atmosphere.

Experiments are being carried on; but they must be on a larger scale if we are to conquer this nuisance. It is a national problem and higher grants must be given by the State to enable scientists to extend their research. Money is being freely spent for armaments and weapons of destruction. Surely it is not asking too much to spend more freely on providing a clean atmosphere free from the dust and fumes which destroy health and beauty.

“THE ADMINISTRATION OF THE LAW AND CO-OPERATION WITH MANUFACTURERS.”

By J. GREENWOOD WILSON, M.D., F.R.C.P. (LOND.)
(Medical Officer of Health, Cardiff).

As this paper is to be circularised in advance and in view of my title, I feel no need to apologise for beginning my paper by reproduction from the Public Health Act, 1936, of the sections relating to smoke nuisances. The reprint of this paper should be more convenient to carry about than the Public Health Act, 1936.

101. For the purpose of this Part of this Act—

- (a) any installation for the combustion of fuel which is used in any manufacturing or trade process, or for working engines by steam, and which does not so far as practicable prevent the emission of smoke to the atmosphere; and
- (b) any chimney (*not being the chimney of a private house*) emitting smoke in such quantity as to be a nuisance,

shall be statutory nuisances and are in this Act referred to as “smoke nuisances.”

102. Where in the opinion of an authorised officer of a local authority a smoke nuisance exists, he shall, as soon as practicable after he has become aware thereof, notify the occupier of the premises on which the nuisance exists, and, if that notification was not in writing, shall, within twenty-four hours after he became aware of the nuisance, confirm the notification in writing.

103. (1) Subject to the provisions of this section, where a smoke nuisance exists on any premises, an abatement notice may be served and a complaint with respect to the nuisance may be made in like manner, and thereupon the like proceedings shall be had, with the like incidents and consequences as to the making of orders, penalties for disobedience of orders and otherwise, as in the case of any other statutory nuisance.

(2) Where proceedings are brought by virtue of this section in respect of such a nuisance as is mentioned in paragraph (a) of the last but one preceding section, *it shall be a defence for the defendant to prove that the installation complained of embodies the best practicable means for preventing the emission of smoke to the atmosphere, and that the installation has been carefully attended to by the person having the charge thereof.*

(3) Where proceedings are brought by virtue of this section in respect of the emission from a chimney of smoke, other than black smoke, in such quantity as to be a nuisance, it shall be a defence for the defendant to prove that the best practicable means have been taken for preventing the nuisance.

For the purposes of this subsection, the expression “best practicable means” has reference not only to the provision and efficient maintenance of adequate and proper plant for preventing the creation and emission of smoke, but also to the manner in which that plant is used.

(4) Where byelaws made under the next succeeding section are in force for regulating the emission of smoke of such colour, density or content as may be prescribed by the bye-laws, the emission of smoke of the character so prescribed for such period

as may be so prescribed either from buildings generally to which the enactments relating to smoke nuisances apply, or from such classes of those buildings as may be so prescribed, shall, until the contrary is proved, be deemed to be a statutory nuisance and a smoke nuisance.

(5) In the case of smoke nuisance, the fine which may be imposed by the court, in respect of a failure to comply with an abatement notice, shall be a fine not exceeding fifty pounds, and the fines which may be imposed by a court in respect of a failure to comply with, or a contravention of, a nuisance order shall be a fine not exceeding ten pounds and a further fine not exceeding five pounds for each day on which the offence continues after conviction therefor.

104. (1) *A local authority may, and if so required by the Minister, shall make byelaws regulating the emission of smoke of such colour, density, or content as may be prescribed by the byelaws.*

(2) *Building byelaws may require the provision in new buildings, other than private houses, of such arrangements for heating or cooking as are calculated to prevent or reduce the emission of smoke.*

(3) A local authority who propose to apply to the Minister for confirmation of any byelaws made under this section shall, in addition to complying with the requirements of section two hundred and fifty of the Local Government Act, 1933, publish in the London Gazette at least one month before the application is made notice of their intention to apply for confirmation.

105. *Subject to such restrictions or conditions, if any, as the Minister may by regulations prescribe, a local authority may undertake investigations and research into problems relating to atmospheric pollution and the abatement of smoke nuisances, and may contribute towards the cost of similar investigations and research undertaken by other bodies or persons.*

106. If it appears to a local authority that a smoke nuisance within, or affecting any part of, their district exists on any premises occupied for the public service of the Crown, they shall report the circumstances to the appropriate Government department, and, if the Minister responsible for that department is satisfied after due inquiry that such a nuisance exists, he shall cause such steps to be taken as may be necessary to abate the nuisance and to prevent a recurrence thereof.

Points deemed to be of special interest in the foregoing extracts from the Public Health Act, 1936, have been italicized, and to these detailed reference will be made. But first of all certain general observations are called for.

It seems to me a misfortune that in the new Public Health Act the method of dealing with smoke abatement by the old "nuisance" procedure should be perpetuated. Indeed, to anyone who thinks as I do, there is a touch of irony in those parts of the Report of the Local Government and Public Health Consolidation Committee in which apology is made for retaining "nuisance" procedure at all on the grounds that to abandon it would make too drastic an alteration of the law, "*and in particular of the important provisions* with regard to smoke nuisances contained in the recent Public Health (Smoke Abatement) Act, 1926." And so for the sake of smoke abatement which (in the *English* law) remains so hopelessly befogged by the legal verbiage relating to nuisances and which of all branches of health administration needs perhaps the greatest help from clarity of legislation, the whole cumbersome business of sanitation by nuisance abatement is retained in the New Magna Carta of English Public Health.

What is a "smoke nuisance"? According to Section 101 it is either any mechanical contrivance operated by processes of combustion for commercial purposes that does not *as far as practicable* prevent the emission of smoke to the atmosphere, or any chimney (*other than that of a private house*) emitting smoke in such quantity as to be a nuisance. But who shall say what is and what is not practicable to prevent emission of smoke to the atmosphere; and what is "smoke"? Does "smoke" include particles of grit, ashes or cinders. At the end (Section 343) of the Public Health Act, 1936, there are a number of admirable definitions of no fewer than 47 different terms that have been used in the Act and in Section 110 we are reminded that smoke includes soot, ash, grit and gritty particles, but one looks in vain in any part of the Act for a definition of *black* smoke. It is true that byelaws may be made by local authorities to regulate the colour, density and *content* of smoke, but all existing byelaws seem to stop at black smoke and go no further. Furthermore, even the byelaws do not give a clear definition of black smoke. Some magistrates will accept Ringelman's charts, but the whole procedure savours too much of makeshift. It is otherwise with the powers that were obtained so long ago as 1892 by the City of Glasgow. They are a model of clarity and the envy of local health administrators in England. Here they are :—

"Every person who so uses, causes, permits or suffers to be used any furnace or fire within the city (except a household fire) as that smoke, grit, gritty particules, sparks, ashes or cinders issue therefrom unless he proves that he has used the best practicable means for preventing smoke . . . being issued and has carefully attended to and managed such

furnace or fire so as to prevent as far as possible smoke issuing therefrom," shall be liable to a penalty.

Then again, what is a "nuisance"—smoke or otherwise? The answer is "something that is prejudicial to health." But who is to say exactly how much smoke and of what quality is or is not prejudicial to health?

Section 103 of the Public Health Act, 1936, defines a smoke nuisance as something in respect of which the like procedure may be taken as if it were a "statutory nuisance." For this again we must turn back to an earlier portion of the Act which defines a number of specific examples of things that are "prejudicial to health or a nuisance" and adds "any other matter declared by any provision of this Act to be a statutory nuisance"—which brings us back round the circle to Section 101, knowing no more than when he started from there. I run the risk of labouring all these points in order to show the wild confusion and deplorable lack of standards in the English law relating to smoke abatement. For water, we have high standards of purity (since the Croydon uproar almost stringent ones). We have low standards of purity for milk. But high or low they are at least standards, assessable by scientific tests, that are recognised by law. Mr. Percy J. Waldram in a recent dissertation upon lighting standards points to the progress that has been made in applying them to the betterment of human environment, particularly through the medium of the Housing and Town Planning Act of 1932, which he hopes will ensure a *legal "birthright" of light and air for British citizens*. Mr. Waldram's optimism may well prove to be justified as to light, and even as to air if we consider *quantity* only, but what of its *quality*?

We are faced with the sad spectacle of trained technical officers, who in the host of their duties might be so much more usefully employed, sitting watching smoke come from factory chimneys for half-hours on end. Does anyone seriously pretend that such time-consuming activities reap a proportionate reward in benefit to the health of the community? Can anyone of intelligence pretend that in these activities based upon smoke byelaws you have a legally-recognised application of scientific standards comparable with that appertaining to milk and water?

I think I have brought you to the second part of the subject allotted to me—Co-operation with Manufacturers. For obviously such progress as we have made has had to depend on that co-operation almost entirely. The law is and has been (outside Scotland) too weak and too confused to be of much use to the administrator. And even if it were stronger, or even when, weak as it is we try to use it, the resort to force brings with it the danger of counter-attack from the manufacturers—especially in these days of borderline industrial depression. "Reduce my

smoke," says the manufacturer, "and I will drastically reduce the number of my employees." For this reason as well as because we have learnt so well in other branches of health administration the value of co-operation, that must always be the method of choice. The difficulties of such co-operation are well illustrated on a large scale by the account in the August issue of the Journal of the National Smoke Abatement Society, which reports (on p. 85) a powerfully-organised opposition to what had seemed a harmless enough experiment in smoke abatement proposed for a carefully selected area in the centre of Manchester.

But to my mind the greatest difficulty of co-operation is related to the greatest crime (of omission) in the law itself. I refer to the smoke nuisance (*enormous* in aggregate) created by the private householder. The law is most careful to protect the domestic hearth from the least attempt at smoke abatement. The position was well summed up by Sir Philip Dawson, M.P., in his address to the Joint Gas Conference at the British Industries Fair, Birmingham, 1938. Referring to the increased consumption of gas and electricity in domestic dwellings he added: "The old offender, the coal range, continues its smoky operations undisturbed. The best that can be said is that the family has increased its comfort without increasing or decreasing its smoke production." Deploring the loss of a great opportunity to prevent smoke pollution in the 3½ million new houses built since the war, Sir Philip concluded: "Thus in our newest housing estates Victorian heating arrangements are perpetuated."

All power to the elbow of the National Smoke Abatement Society which seeks to create a smoke conscience. Success will be rewarded by new and better legislation, in which I should like to see a clause beginning like this: "The Minister may make regulations." And then I should like to see wise and comprehensive regulations made under that clause by the Minister of Health, regulations that would have national application, transcending the vagaries of local nuisance procedure.

One last point, and that in favour even of the existing law. Section 105 enables local authorities to contribute towards the cost of research. Cardiff City Council was one of the first local authorities to subscribe to the Standing Conference of Co-operating Bodies (Atmospheric Pollution), one of the first to join the National Smoke Abatement Society, and one of the first to take readings of atmospheric pollution with a deposit gauge.

I am sure they have never regretted a penny of the money spent in this way. What is needed is strongly legalised practical application on a national scale of the results obtained by research.

REFERENCES.

THE PUBLIC HEALTH ACT, 1936.

MACGREGOR, A. S. M. (1937). "Public Health Administration and Smoke Abatement."

WALDRAM, P. J. (1938), London; P. S. King & Son Ltd. "Report on the Possibilities of securing adequacy in the National Lighting of Dwellings by Regulations under the Town and Country Planning Act, 1932."

DAWSON, P. (1938), London; B.C.G.A. Publications. "Smoke Prevention."

"THE TRAINING OF STOKERS."

By SYDNEY N. DUGUID, B.SC.(TECH.), M.INST.F., M.R.SAN.I.

A man fully employed in shovelling coal into boiler furnaces may burn up at least £2,000 of the owners' money in twelve months. With a large boiler plant, mechanically stoked, this sum may be exceeded many times over.

Inefficient handling of boiler plant may result in anything up to 33½% of the fuel being wasted.

What more need be said to show the necessity of having properly trained men on the firing floor?

In other departments the handling of costly raw material is usually done by skilled operatives but in the boiler department trained firemen are the exception and not the rule.

It may be argued that boiler firemen usually work under the supervision of an engineer who should be able to help them in their difficulties. The duties of an engineer employed by the average manufacturing concern are so multitudinous that he rarely has time to spend more than a few minutes each day in the boiler house. His head may be simply bursting with knowledge relating to combustion and smoke abatement problems but of what use is it if he is not there to impart it at the required moment.

The men who spend all their working hours on the firing floor should be able to deal with every difficulty that is likely to arise.

The idea that physical strength is the only necessary qualification of a "fire-beater" (as we used to call boiler firemen in Lancashire), has died a lingering death, but it is still doubtful whether the extent of the training necessary to produce the complete fireman has been sufficiently recognised.

The job of operating boiler plant is an occupation for a highly skilled man and when this view is universally accepted the status of boiler firemen will be raised and men will be glad to train for the position instead of just drifting into it as they seem to do at present.

Most people when boiler firemen are mentioned at once conjure up a vision of a man with a large shovel but we must not forget that stoking by mechanical appliances is making rapid headway, and automatic control of boiler plant is also slowly but surely being adopted. The mechanizing of boiler plant will not, however, solve the question of training the attendant but make it more acute as such plant demand the services of more highly skilled men than do hand fired types.

Contrary to popular belief the majority of boiler firemen know how to handle the shovel efficiently. The different methods of throwing coal on a fire can be explained in a very short time and dexterity is soon acquired with practice. The training should therefore consist essentially of those matters which cannot be picked up in the boiler house. Given a comfortable room, an O.S. blackboard, plenty of chalk and a lantern, it is possible to impart more useful knowledge in an hour than could be done in a week spent on the firing floor.

The principles governing efficient and smokeless combustion are the same whether the fire is in a kitchen grate or in the furnace of the largest boiler, or in Cardiff or Auchtermuchty, and once these are firmly grasped they can be applied to any plant with results beneficial to the owner and the neighbourhood in which the works may be situated.

It may be possible to instruct a man to stoke a particular boiler plant with one particular class of coal without him understanding anything of the principles upon which his actions are based but what good would that be when a change in the quality of the coal might make it necessary to teach him all over again?

Firemen are not fixtures and they sometimes transfer their services to another firm. As no two boiler plants behave in the same manner, and even individual boilers in the same battery require different treatment, it may be appreciated that particularized instruction is of little worth.

Training.

A boiler fireman can only be considered fully trained when he can go to any boiler plant, burning any type of fuel, and operate it efficiently and without creating a smoke nuisance. To produce men of this grade a course of at least forty lectures is necessary and it is best to hold them in the evenings of the winter months and extend them over a period of two years, that is, give 20 lectures the first year and 20 the second. By this arrangement the men have the summer in which to recuperate.

Each lecture should never last longer than one-and-a-half hours, because after a hard day's work it is difficult for men to concentrate for a longer period particularly when mental effort of the kind necessary has not been indulged in for many years.

One and a quarter hours is, in the writer's opinion, the ideal length.

At the end of most of the lectures a question should be set, to be answered in writing, at home, and handed in at the next lecture. Scrutinizing and awarding marks for these exercises is a most important part of the lecturer's duties, as it enables him to judge whether the class as a whole has thoroughly understood the matters about which he has been speaking. The labour of answering such questions teaches a student to express himself clearly and prepares him for the written examination which should be held at the close of each winter session. The percentage of marks received for homework exercises, should be taken into account when judging the results of the examination.

Visits to works where boilers are under construction and to large plant such as Electricity Generating Stations are definitely educative and entertaining. These have usually to be arranged for Saturday afternoons and to secure the maximum attendance it is necessary to study the local football fixtures before deciding the date of the visit.

Courses in Manchester.

At the College of Technology, Manchester, two well-attended courses on the lines suggested in this paper have been run for a number of years.

They are described in the prospectus as follows :—

Boiler House Practice I. 7-30 p.m. to 8-45 p.m.

An elementary treatment of the subject with special reference to Smoke Abatement and Fuel Economy, suitable for boiler firemen, engineers' and coal merchants' representatives and others who may **not** previously have had technical training, including :—Coal, its composition and origin. Combustion. Boilers of various types. Furnaces, hand-firing, mechanical stokers, draught, chimneys, flues, economisers. Smoke and its evil effects. Feed water, scale, water softeners. Causes of inefficiency. Boiler-house instruments.

Boiler House Practice II. 7-15 p.m. to 8-45 p.m.

A more advanced treatment of the subject, including :—Coal : origin, composition, characteristics and uses of different kinds—powdered coal. Other fuels—gas, oil, gas coke, low temperature carbonisation coke, electricity. Chemistry of combustion; production and transmission of heat. Steam : properties, steam tables, steam calorimeter, steam engine indicator. Boilers : Lancashire, firetube, water tube, waste heat. Furnaces : hand firing, mechanical stokers. Draught : natural, induced, forced, balanced, chimneys, flues. Economisers : superheaters, air preheaters. Feed water, scale, water softeners. Boiler-house instruments : feed-water meters, steam meters, coal meters, CO₂ Recorders, draught gauges, thermometers and pyrometers, fuel calorimeters. Heat efficiency of steam boilers : the evaporation test, the heat balance, principal causes of inefficiency, importance of the human element, examples of waste. Smoke : nature and composition, cause, measurement of density, and colour; effect upon health, buildings, vegetation; prevention. Laws : by-laws and regulations affecting the emission and prevention of smoke,

Men who have had some previous training and possess an elementary knowledge of Chemistry and Physics are allowed, if they wish, to enter Course II without having passed through Course I.

Course II is approved by The Royal Sanitary Institute as a training for those wishing to sit for the examination for the Smoke Inspectors' Certificate, issued by the Institute.

The fee for Course I is 5/-, and for Course II 7/6.

On the results of the examination of Course I students, the Manchester and District Regional Smoke Abatement Committee grants a Certificate.

A certificate is given by the College to all students who pass the Course II examination.

Typical Examination Papers.

The following are the questions set for the examinations at the close of the Winter Session 1937/38 :—

Boiler House Practice I. 7-0 p.m. to 10-0 p.m.

Candidates are required to attempt not more than SIX questions.

1. What effect have (1) Moisture, (2) Fixed Carbon, (3) Volatile Matter and (4) Ash, upon the value of a coal used for steam raising purposes?
2. Describe the differences in design between a standard Lancashire boiler and an Economic or "dry-back" boiler, and state the advantages claimed for the latter.
3. How is draught intensity measured?
What may cause a shortage of air in furnaces even when there is ample draught intensity at the chimney base?
4. Explain what is meant by the term "excess air" and say how you would proceed to measure it in the case of a Lancashire boiler plant.
5. If a man who was hand firing a cylindrical boiler for the first time asked you for advice, what would you tell him?
6. Why should a boiler plant be fitted with instruments?
In what particular way do (1) Steam Meters, (2) CO₂ Recorders and (3) Draught Gauges, help the boiler house staff?
7. Describe an apparatus suitable for softening hard feed water before it enters a boiler plant.
8. What effect has a smoke polluted atmosphere on (1) Health and (2) Vegetation?

Boiler House Practice II. 7-0 p.m. to 10-0 p.m.

Candidates are required to attempt not more than SIX questions.

1. What items make up a "proximate" analysis of a coal and what information does each give regarding the value of the fuel for steam raising purposes?

2. What precautions should be taken when collecting and preparing a sample of coal for purposes of analysis?
Assume that the sample has to be taken from a large pile of small coal situated on the boiler house floor.
3. What are the principal differences in design of (1) Lancashire, (2) Economic and, (3) Watertube boilers?
4. Describe two methods by which bituminous coal may be used, without causing a smoke nuisance, for boilers serving low pressure hot water heating systems.
5. What advantages does forced draught produced by a fan possess over natural draught, and what precautions should be taken when applying it?
Describe an instrument suitable for measuring the volume of air flowing in the duct between the fan and the furnaces.
6. If you were asked to construct a "Heat Balance" for a plant consisting of boiler, superheater, and economiser, what items would you calculate?
7. Describe briefly three methods of extracting the impurities from flue gases so as to reduce atmospheric contamination.
8. What effect has a smoke-laden atmosphere on (1) buildings and (2) vegetation?

The following table gives the attendances and examination results for the last six years, at the College of Technology, Manchester :—

Session	1932-33		1933-34		1934-35		1935-36		1936-37		1937-38	
Course	1st y'r	2nd y'r	1st y'r	2nd y'r	1st y'r	2nd y'r	1st y'r	2nd y'r	1st y'r	2nd y'r	1st y'r	2nd y'r
Number enrolled	93	53	39	63	30	52	47	55	48	59	62	76
% attendance ...	78	66	79	79	76	77	84	79	73	70	79	72
Number ex'mnd	60	31	26	47	22	35	41	36	34	39	49	41
Number passed	56	24	24	42	20	27	35	28	25	27	35	34
% passed	93	77	92	89	91	77	85	78	74	69	71	83

Many employers encourage the men to attend the lectures by paying the fees and, where necessary, travelling expenses.

Nothing has been said about the qualifications of the lecturer but obviously he must be a man who is familiar with the work done on the firing floor and have a wide experience of the operation and testing of all types of fuel burning plant. Above all, he must have a sense of humour.

DISCUSSION.

Mr. J. A. Robinson (Bristol) speaking with regard to Dr. Greenwood Wilson's paper, which he had conveniently divided into two parts viz. Legislation and Co-operation with Manufacturers, said he was sorry that Dr. Wilson appeared so pessimistic as to the legislative powers we possessed to deal with the nuisance. Much good had already been done and he took a more optimistic view of the question.

Dr. Wilson asked what is a smoke nuisance? and he was surprised when he heard him say that he had looked in vain for any definition of smoke.* It was very clearly defined in Section 110 of the Public Health Act, 1936, and included soot, ash, grit and gritty particles.

That definition had been extremely useful in Bristol. An institution had been giving a great deal of trouble with undue emissions of smoke, and after much consultation and persuasion, the Committee authorised the expenditure of over a thousand pounds in installing patent stoking grates. This cured the smoke but gave rise to a greatly increased nuisance from dust which got into the houses adjoining and the tenants were compelled to keep their windows closed to prevent the dust contaminating their food. This problem was in course of being solved.

With regard to co-operation with manufacturers he had not met with much difficulty, in this respect. When he had had to interview works' managers and point out to them that smoke meant wasteful and costly misuse of fuel, they were always ready to listen to advice and were anxious to adopt reasonable measures. He had found them very helpful and it was his experience that considerably more could be done by education and suggestion than by the threat of legal proceedings. After all, as sanitary inspectors it was their duty to take observations of chimney stacks for the recognised period and in case of infringement of bye-laws to take such measures as would abate the nuisance. It was not always easy to point out a remedy, which would be effective in every case, but any suggestion was invariably tried.

Thos. M. Ashford (Glasgow) said he was glad that Dr. Greenwood Wilson had focussed attention on the unfortunate perpetuation of the "nuisance" procedure in dealing with smoke problems under the new Public Health Act, 1936. The legal definition of a nuisance, and particularly a smoke nuisance, had always presented the greatest difficulty to the administrator, and it was indeed vexatious that his troubles in this direction had not been made any easier by the continuance of this antiquated procedure. Dr. Wilson had also dealt with the "extraordinary difficulty" of proving the "best practicable means." In his (Mr. Ashford's) opinion the technical official should not experience much difficulty in this connection and if he could not prove the *best* practicable means he could at least prove *better* practicable means for preventing the excessive emission of smoke, which would include careful attention and management. This, at any rate, was the position in certain localities in Scotland where

* The statement referred to has been corrected in the final draft of Dr. Wilson's paper, as printed in this report.

the local statutes were drafted in a more water-tight fashion than was the case south of the border. To this Dr. Greenwood Wilson had also referred in his paper. There was now at least the advantage south of the border in that there could be some uniformity of legislation under the provisions of the general Act, whereas in Scotland this was not so. There the only powers available were those contained in the Burgh Police (Scotland) Act, 1892, Section 384, and which was not applicable to every area of the country. In addition, it contained many exemptions which meant that in certain areas where definite legislation was most desirable it became virtually inoperable as the exemptions mentioned constituted the staple industries in these extensive localities. Owing to this lack of uniformity of legislation there were consequently many anomalies existing. This position could only be rectified with the inception of a general act for Scotland with a greater clarity of statement and procedure than that which existed in England. The smoke regulation in the Glasgow Police (Further Powers) Act, 1892, with which he was intimately connected, possessed a clarity of statement and enabled a direct procedure to be adopted, even although there was no attempt made to define standards of density or duration of smoke emission. In this way administration was wholly functional and in no way mechanical. Some reference had been made to the domestic component of the problem and in this connection he was definitely of the opinion that, while the extended use of gas and electricity would be an important contributory factor in its solution, only when adequate supplies of suitably prepared fuels were available for use in standard open fire grates could any useful coercive legislation or control be effected. One had always to have in mind the important question of satisfactory ventilation of living apartments. First "realisation" and then "co-operation" by plant users and by the public will be the corner stones in the elimination of this "nuisance" and menace to health amenities.

Mr. Ashford disagreed with Mr. S. N. Duguid's statement that written homework was very necessary or that men, before they could prove that they had a knowledge of the subject, must be able to express themselves in writing. On the contrary, during his very extensive experience in this work, he had come across many men who possessed a very intimate knowledge of the subject which they could put into every-day practice with very beneficial results, and yet were quite hopeless when attempting to express themselves on paper. Mr. Duguid had suggested during the elaboration of his paper that a third year's Advance Course was desirable. He doubted the advisability of this and wondered if this highly technical training of boiler and furnace stokers, etc., was not over-reaching itself. Was there not a danger in engendering in many men ambitions which they could not possibly realise? This opinion had been expressed to him by many men during the course of his experience. Mr. Ashford said that Glasgow was probably the first centre to adopt a systematised course of technical study. The classes there, both ordinary and advanced, had been incepted in 1910 and since that date (excluding the war years) 2,129 men had passed through the classes. Since 1930 the number enrolled had been 1,072, the percentage attendance in both classes

being 89.7, and the percentage of candidates sitting the examinations being 43; the pass figure was 73 per cent. Classes had also been organised and run successfully for a number of years by the Edinburgh Public Health Department, in conjunction with the Herriot-Watt College, and successful classes had been organised from Glasgow in surrounding industrial areas during several years, the results being most gratifying. In his opinion the educational aspect was a very necessary adjunct in the general work of smoke abatement.

Concillor S. J. Ballantyne (Fulham) said he wished first of all to thank Dr. J. Greenwood Wilson and Mr. Duguid for the interesting and instructive papers they had given. As he had stated, he represented Fulham, where they had the largest municipally-owned electricity base load station. At the inception of the scheme they were opposed by the surrounding Boroughs on account, as they thought, of the smoke nuisance likely to arise, but he was pleased to say they had already installed a plant at great cost to purify anything which might be emitted in the air. His contribution to the discussion would be concerned with the question of domestic smoke mainly because there was, as far as Councils were concerned, legislation to deal with the other aspects of air pollution.

If it were in his power to abolish by edict the use of open fires, burning coal or wood, he supposed that the appalling damage to health and he believed the relatively much greater damage to property, would oblige him to say that the fumes and soot were too great a price to pay for the advantages of the open fire. It was true that to a great extent open fires wherever possible were preferred when warmth and comfort were required for long periods, and he thought there they had a very strong piece of evidence for the view that human tastes and inclinations and real psychological need would change only very slowly. It would be interesting to find out the annual cost to the rates resulting from the harmful products of combustion in domestic premises. There were millions of open fires in the country which, notwithstanding the supplies of gas and electricity, would continue to be open fires unless the Local Authorities, in conjunction with this Society, created amongst the people the urge for a cleaner and healthier atmosphere.

The only way to stop smoke was to stop burning raw coal and the only way to do this was to provide a solid fuel which gave warmth and comfort without polluting the atmosphere with tarry smoke. In the replacement of raw coal by solid smokeless fuel the greatest effort had been made by the producers of gas coke. How could local authorities complete the picture of a smokeless land? By seeing to it that, in putting up new houses and flats, suitable grates were installed for burning coke, together with gas or electricity for cooking or heating purposes where a regular fire was not required. These grates would cost no more than ordinary grates. Facilities should be promoted for the sale of coke and other solid smokeless fuels in small quantities where accommodation was limited. It would be helpful if Housing Managers or persons engaged in the supervision of housing estates possessed a practical knowledge of the principles of smokeless heating.

Local authorities could do a lot more in smoke abatement propaganda and make this a bigger feature of their Health Week. Pamphlets could be issued from Public Health Departments telling of one of the greatest enemies of health—atmospheric pollution.

Local authorities were becoming owners of large housing estates, so that to a considerable extent the remedy was in their own hands. This could be assisted if the great selling agents, in the interest of smoke abatement, would help to accelerate the installation of open grates suitable for burning smokeless fuel and if the local authorities educated the people to the use of smokeless fuel. Then the result would be a smokeless England.

Mr. J. W. Beaumont (Halifax) said that with respect to Dr. Greenwood Wilson's paper, Mr. Robinson had already pointed out that "smoke" was clearly defined in Section 110 of the Public Health Act, 1936, and that he wished to call attention to Dr. Wilson's statement that a nuisance was "something that is prejudicial to health." Mr. Beaumont went on to point out that under the Public Health Act, 1936, it was not necessary to prove that a nuisance was prejudicial to health.

Referring to local authorities Mr. Beaumont stated that they should set a better example than they do at present, by seeing to it that all public buildings under their control were heated by entirely smokeless methods. There was plenty of evidence to indicate that smoke abatement propaganda was as necessary to members of local authorities as to the "man in the street."

Referring to the paper on "The Training of Stokers" by Mr. Duguid, Mr. Beaumont said it was regretted by all that Mr. Duguid should have had to leave the meeting. He would have been glad to compliment him upon his most excellent paper, and to ask the secret of the success of his classes. In the area of the West Riding Regional Smoke Abatement Committee there had been a fall in the attendance of stokers at classes, due largely to the lack of support by manufacturers who should not only provide facilities for stokers to attend such classes but pay all incidental expenses in addition.

Mr. George W. Farquharson (Birmingham) said that Dr. Greenwood Wilson gave rather a pessimistic view on the law in the Public Health Act 1936 relating to smoke. One must agree that lack of standards to guide the local authorities in their administration was a necessity urgently required towards obtaining uniformity throughout the country, but to use his term of "wild confusion" he thought it was a little extravagant. The Act was there and the administrators had to tackle it as it stood. What was the procedure? Briefly—

- (a) Duty of local authority to inspect district.
- (b) The notice to occupier of the existence of a smoke nuisance by the authorised officer.
- (c) The service of an abatement notice by the local authority.
- (d) If the abatement notice was disregarded the authority shall cause a complaint to be made to a Justice of the Peace and the Justice

issues the summons for the case to be heard in the Court of Summary Jurisdiction.

- (e) The Court made the order to abate or otherwise. The order was called the "Nuisance Order."
- (f) If the Nuisance Order was not complied with contravention of this order was subject to heavy penalties, and finally the local authority might carry out the work necessary and recover the costs.

The procedure was slow but not confusing.

Dr. Greenwood Wilson asked—what was a smoke nuisance? As he said the answer is in Section 101, i.e.,

(a) The installation.

(b) The chimney (not being the chimney of a private house).

They were the two factors to which the notices and orders applied. He asked "Who shall say what is and what is not practicable to prevent the emission of smoke to the atmosphere." We would ask him, that seeing this phrase applies to the installation, did he not agree that the authorised officer who in the first place formed the opinion on behalf of the local Authority should have the technical knowledge and ability to decide that? If he had not, how could the abatement notice be served requiring any work to be done, to obtain better combustion in the installation, and did he not agree that this technical section might be one of the main reasons why, as he put it, "the time spent in watching chimneys reaps little reward."

Referring to Mr. Duguid's paper, Mr. Farquharson said that recently the classes on smoke abatement had been started in Birmingham. The syllabus drawn up by Dr. W. R. Martine, Assistant Medical Officer of Health and himself, was similar to the one in Mr. Duguid's paper.

He would like to know what percentage of actual employees in industry attended the courses at Manchester, because they had found that last year only a small percentage of the students who attended came from the works in their city. Most of the students were from adjacent local authorities eager to gain additional knowledge and the younger members to qualify for the Smoke Inspector's Certificate.

Again, was the course run by the Education Committee in conjunction with the Manchester Regional Smoke Abatement Committee? If so, were the courses advertised, or were the local works circularised, asking for their support?

After all where was the smoke made? At the firegrate end, and that is where it had got to be cured.

Mr. Farquharson agreed with the doctor's remarks on byelaws. The present byelaws were out of date and the Ministry should issue model byelaws for the guidance of local authorities, to cover smoke emissions from boilers, metallurgical furnaces, kilns, ovens, etc., not for boilers only.

He noted Dr. Greenwood Wilson had omitted to quote on Section 109—the so-called qualifying or saving clause relating to mines, smelting and heat treatment of metals, etc. As far as he could foresee this section was going to be a controlling factor in the measure which had reached its

second reading in Parliament relating "to an accumulation of refuse from a coal mine which is liable to spontaneous combustion" should be deemed to be a statutory nuisance and liable to be dealt with under the Public Health Act. He had also not referred to the Section 267 dealing with ships.

In his remarks on co-operation he would ask him—did he not agree that co-operation with manufacturers was essential? At the same time a steady pursuance of the law was the only remedy to secure any results if that co-operation failed.

Mr. Turner (Fulham) said that Dr. Greenwood Wilson in his paper asked "What is Smoke?" To the laymen smoke is the visible vapour from burning fuel. This conception had been legally extended to include smoke, ash, grit and gritty particles and Mr. Turner thought that the time was fast approaching when a limit of sulphur gases should be included. Previous speakers had mentioned the new Fulham Power Station, where plant working extremely efficiently, almost entirely eliminated sulphur from the flue gases, a point Mr. Damon could confirm.

There were, however, three other electric power stations, within 200 yards of their boundary, burning enormous quantities of coal without any attempt to remove sulphur from the effluent gases. These stations were located in the South Western district of London and the prevailing wind carried the pollution from their many shafts over the whole of Central London and nothing could be done to stop it.

Alderman J. B. Shimmin (Leyton) suggested that up to the present the Society had carried out the very necessary work of propaganda and education. Now, however, there were a number of local authorities which were progressively minded in respect to the smoke problem, and given a lead from the Society some of them might be prepared to arrange conferences in their own areas, with local bodies that were interested in social well-being, to consider especially the domestic smoke problem.

Whilst thus relieving and extending the work of the Society they would help to create a greater smoke consciousness on the part of the community.

Mr. Damon (Ministry of Health) referring to the operation of gas washing at Fulham, said that the plant resulted in the reduction of acidity in the chimney gases to a figure of about 0.006 grain (as sulphur) per cu. foot. This was a most satisfactory achievement but the cost was a serious item. Lead peroxide cylinders had been exposed in the neighbourhood of the station both before and after it was put into operation and the results indicated no increase in the sulphur oxide pollution of the atmosphere. It was remarkable that a station could consume half a million tons of coal per annum without any appreciable effect on the atmosphere in the neighbourhood.

With regard to the training of stokers Mr. Damon said that employers should encourage attendance at the classes. He thought that employers should be willing not only to pay the tuition fees but also to reward those who took certificates by paying them an increased rate.

Mr. G. H. Barnard (Coal Utilisation Council) suggested that the paper dealt with the problem from the wrong angle and recommended the training and education of directors and factory managers in boiler house management.

He intimated that no stoker, however highly trained, could prevent smoke emission from an overloaded boiler. He made a plea to directors of industrial concerns, for the sanction of expenditure in the boiler house for essential instruments. Without the aid of such instruments, stokers were working in the dark.

The speaker indicated that the paper described an ideal form of training, but in practice there were difficulties in carrying out the same. One of these difficulties was that there are few Technical Schools which offer such courses of instruction, and requested that delegates who were members of Education Committees, should press for such courses with their directors of education. He pointed out that shift work reduces attendance and that the majority of stokers are past the age of students.

Mr. Barnard also indicated what the C.U.C. Area Engineers were doing in the practical training of stokers on site.

Mr. James Law (Sheffield) said he had listened with considerable interest to Dr. Greenwood Wilson's paper and admired his courage in opening up a subject that had for a long time caused so much controversy. "What is a smoke nuisance?" he asked.

A smoke nuisance for the purposes of the Act was the emission of smoke in excess of the prescribed standard—probably two minutes per half hour. Smoke was excessive when it became opaque at the chimney top, irrespective of the colour.

The smoke was emitted from the chimney, but this emission was definitely caused by abnormal conditions at the installation end. There should be no confusion about the chimney or the installation attached to it.

"The sad spectacle of the trained technical officer watching smoke emitted from chimneys for half hours on end" was a very essential part of smoke abatement work. If systematic observations were not made, how could it be ascertained if a prescribed standard had been exceeded? How was one to know whether the cause was carelessness or excessive steam demand? The observation was the first part of the work and the inspection of the plant and conditions the second. Anyone with engineering and combustion knowledge would be able to tell from this the cause of the nuisance and could suggest the remedy for the same. If the trained technical officer had not this knowledge, he would agree with Dr. Wilson that he was only wasting his time.

Combustion, like medicine, was not yet an exact science, but there were fundamental laws which must be adhered to. There were also scientific standards for the examination of products of combustion or flue gases, but they were not quite so easy to determine as standards of milk and water. A sample of milk or water could be easily obtained and chemically or bacteriologically examined, but a sample of gas being emitted from a chimney was not so simple. Did a doctor go and look at a

patient and diagnose his complaint immediately? Yet in many cases the diagnosis of a human illness was simple in comparison to the cause of a nuisance at a large boiler house.

With regard to co-operation with the manufacturers, he was sure that everyone would be in entire agreement with Dr. Wilson. Without co-operation progress was impossible. Dr. Wilson was postulating the theory that all manufacturers were willing and anxious to co-operate, but were they?

During the past twenty years, experience had shown that co-operation more often took place after the service of a Statutory Notice or the making of a Magistrate's Order to abate the nuisance than at any other time. If there was no legislation to control the nuisance or to support the Inspector with his work, there were many individuals who would not co-operate in any way. The Sheffield area was a good example of this with its many metallurgical process chimneys, which, at the present time, were provisionally exempted from the Public Health Act. Ample evidence could be shown that these nuisances were unnecessary, but as long as the provisional exemption remained there were manufacturers who were content to continue with their old and obsolete methods.

The Public Health Act was weak in places, no one could deny that, but if the existing Act was used with knowledge and tact, it could be of service to the community.

If co-operation was to be successfully carried out, the Inspector must have a thorough knowledge of his subject and be in a position to discuss the practical and technical difficulties that occurred in every steam generating or process plant.

Councillor A. Vowles (Neath R.D.C.) said it was with keen interest he had read Mr. Wilson's paper, hoping to find somewhere in it something that would be helpful to the authority he represented to assist them to abate the terrible conditions that their people lived under as a result of colliery screening plant and pulverised fuel stations. He regretted, however, that he had looked in vain.

Previous speakers had said Dr. Wilson had been too pessimistic, but he did not agree. He thought the speaker had asked them to face hard facts, and it was the duty of the Society to do that. It seemed to him that so long as the Act remained as it was it was futile to prosecute any employer if he made any attempt to abate the nuisance, even though that attempt was not *serious*.

He would like to give an idea of the appalling conditions in his area. They had heard a great deal of the smokeless fuel produced in South Wales. That was quite true, but because of the intensified grading of the coals they had to suffer in consequence. They had made a test by placing bowls in certain parts of the district, one being two miles away from the pulverised fuel station and colliery screens. These were kept under strict observation for a month and then submitted to Professor John Sugden of the Cardiff and County Public Health Laboratory. The amazing report they received was that a mixture of small coal and grit was falling over

the area at a rate of 247 tons of combustible matter and 78 tons of mineral matter per square mile per month—a total of 325 tons.

Mr. Vowles asked the meeting to try to imagine what that meant to the people living in the district. Professor Sugden had said that the lowest class, D, of the Investigation of Atmospheric Pollution was combustible matter 18 tons, mineral matter 26 tons.

They had tried to co-operate with the employers and it was only fair to say that there had been an improvement, but very slight. When he said that one firm which took on a contract to collect the dust on a colliery screen made a test, and found that 80 per cent. of the dust passed through a mesh of 105,000 holes to the square inch. He knew it was incredible, but it was a fact. It was so fine that although people kept their windows closed continuously, it went through every crack, and several times each day the womenfolk had to wipe a film of dust off everything.

Meetings of protest had been held and the local authority had been accused of being apathetic. But their hands had been tied because the employers were making efforts.

In respect to co-operation, he agreed that many employers did co-operate. But one to whom they wrote, asking him to abate a dust nuisance, replied that the only way to stop the dust was to close the works, and as it was the unemployed men from the village he had put on the responsibility for stopping them would be the local authority's. It was to meet such cases that he would like to see the legislation strengthened.

He hoped the Society would use all its powers and influence to improve the Public Health Act relating to smoke nuisances in order to alleviate the real misery of his section of the community.

Dr. J. Greenwood Wilson, in replying, suggested that the pessimism in his paper to which so much reference had been made had been fully justified by the interesting discussion that it had evoked. He reiterated his regret that smoke abatement should have to be dealt with by nuisance procedure and insisted that although the change of the word "injurious" in the 1875 Act to "prejudicial" in the 1936 Act was an advantage it was the only respect in which the 1936 Public Health Act provisions dealing with smoke abatement had advantage over the 1926 Smoke Abatement Act. He still maintained that for a definition of any kind of nuisance, whether sanitary or otherwise, it was necessary to fall back on case law and he thought that that was so much less convenient from the point of view of local administration than clear-cut legal provisions in an Act of Parliament itself such as the City of Glasgow Act that he had quoted, or national regulations based upon an Act. He deprecated the existence of byelaws varying in different localities, especially as smoke was apt to drift from the area of one local authority over that of another. National regulations of the same kind and having a similar application in all areas would obviate such difficulties. He concluded by stressing the need for dealing with domestic smoke and thanked the speakers for their instructive criticisms of his paper.

Mr. S. W. Duguid, replying, thanked those who had praised his paper and the critics who had let him down so lightly.

In Manchester they had attempted to raise an educational ladder to serve not only boiler firemen but all concerned with Combustion Engineering. It was intended to meet the needs of those who were only capable of climbing a few rungs, and also of those who wished, and had the ability, to reach the top. The Manchester system had been built up to meet the needs of the men concerned. What was now the 2nd year course was commenced in 1912. The first year course was organised in 1932, at the suggestion of the Manchester and District Regional Smoke Abatement Committee, specially to meet the needs of boiler firemen, and the desire for further instruction caused a substantial number of the 1st year men to enrol for the 2nd year course. A 3rd year course was inaugurated in 1934 simply because a sufficient number of 2nd year students asked for it.

The foregoing was, he thought, a complete reply to the suggestion that the course of training was too elaborate or approached from the wrong angle. The men would not attend if the instruction given was beyond their powers of understanding or not of a helpful nature.

The idea that boiler firemen might be persuaded to do written homework was his own. It caused a good deal of merriment and many people were sceptical as to the possibility of it.

Experience had convinced him that written homework was a valuable part of the training. It led to clear thinking. Over 90% of the men did it, and some after being absent from a lecture, asked permission to attempt the question which had been set in their absence.

Some of the men had secured higher wages and others better jobs as a result of the classes. The latter were not lost to the smoke abatement movement but were frequently able to apply their knowledge over a wider field, which was all to the good of the cause.

The classes were a definite part of the regular evening instruction provided by the Department of Mechanical Engineering, of the College of Technology, Manchester. They were organised by the Head of the Department, Professor Dempster Smith (who was very sympathetic towards the objects of the National Smoke Abatement Society) and who had done everything possible to make them a success. The classes were described in the College syllabus and the attention of local employers was drawn to them by a leaflet issued by the College authorities.

The Manchester and District Regional Smoke Abatement Committee sent posters, and leaflets, to all its constituent local authorities, which numbered about 60, and these were displayed or distributed in each district.

The students were drawn fairly evenly from industrial districts within a 15-mile radius of Manchester. The percentage of students who worked in Manchester varied considerably, the highest being about 40% which was reached in the years when the men from the Manchester Corporation Hospitals and Baths attended.

Men studying for the Smoke Inspector's Certificate had been drawn from so far afield as Blackpool, Wallasey, Stoke-on-Trent and Crewe.

The total number of students who had attended the classes since 1912 was about 1710 and of these, 1004 had enrolled since 1930. Each class met 26 or 27 times each session.

An appreciable number of employers encouraged their men to attend the classes by paying the fee and train or bus fares. The following letters from Mr. J. B. Hudson, Engineer and Manager, Corporation Electricity Department, Leigh, Lancs., was typical of this attitude :—

“I am in receipt of your letter of the 3rd inst., and am glad to note that two members of my Boiler House staff are taking the second year class in Boiler House Practice and I shall be pleased to do all that I can to facilitate their regular attendance.

“I am of the opinion that the training given to these men is of great value in their every day work and it may interest you to know that I had no difficulty in persuading my Committee to refund the out-of-pocket expenses incurred by the men who attended your classes last year.”

Mr. Duguid concluded by saying that if any member of the Society should desire further information on any of the points raised he would be happy to supply it as far as he was able.

Friday Afternoon, 2nd December: 2nd Conference Session.

Opening Remarks by the Chairman, Professor Ralph M. F. Picken, B.Sc., M.B., Ch.B., D.P.H., (Mensel Professor of Preventive Medicine, Welsh National School of Medicine).

The relation between atmospheric pollution and health is now so fully recognised that I need scarcely do more than mention it. The long-term influences of a smoke-laden atmosphere on the respiratory passages, and of the occlusion of light of the sky on our vital processes have never, to my knowledge, been accurately measured. Periodically, however, we do get demonstrations of the effect of smoke when the foggy seasons of the year bring to polluted towns an accentuation of the rise in mortality from respiratory diseases, which affects to a lesser extent those other regions where the air is clear; and occasionally we may observe such dramatic effects as the sudden devastation which fell on the Meuse valley in December, 1930, under meteorological conditions favourable to the concentration in the air of gases which are ordinarily the product of the combustion of coal.

The action of environment on health is a complex problem, or series of problems. We cannot have a fit people without material prosperity, without the means of buying enough of the right kind of food, without the reasonable comforts and amenities of life, without costly services, medical, educational and of other kinds. These provisions depend on industry and trade. But prosperity is not enough. A community can pay too dearly for its thriving industry, and a toll of debility is one of the penalties the people of an area may suffer if industry is fostered without regard to the detrimental effect its emanations may have on the air and light on which their well-being so largely depends.

In this city you see an area which has escaped the grosser forms of atmospheric pollution. The reasons are probably various. For one thing—perhaps the most important—it has a low density of dwelling houses per acre; the houses are largely fuelled by gas or electricity or both; such smoky industry as it harbours is mainly situated where the prevailing winds carry the smoke away from the city; its coal is largely of a kind which burns with a short flame and little smoke. I understand that practically every house in Cardiff has either a gas-cooker or an electric cooker—a rough indication of the extent to which smokeless methods of heating have been adopted. Whatever the reason may be, when you climb the tower of this Hall—which I hope some of you will do—you will be very fortunate if the fair view to the north, west and east is in the least obscured. The buildings in this park at the centre of the city, some thirty years' old, show little mark of stain

or erosion. Yet Cardiff City Council have not assumed that they will be permanently immune.

Observations have been made constantly over a fairly long series of years with the standard gauge, the automatic filter, the lead peroxide method of measuring sulphur pollution, the acetone-methylene blue test for ultra-violet radiation and the sunlight gauge. These observations have been made both in the geographical centre of the city and in the area with most industrial pollution. The results compare favourably with the least smoky areas in the country. Cardiff is in a position to know if and when returning prosperity brings with it a danger of rising pollution and no doubt the City Council will take appropriate steps to deal with it.

Some of us have felt disappointment that the movement toward the production of smokeless fuel in South Wales, which was begun a good many years ago by Dr. Illingworth, has made so little progress. Both from the public health standpoint and that of industry in the area we had hoped for substantial developments in this direction. No doubt there were technical and commercial obstacles to be overcome, about which we may hear something in the forthcoming discussion, but it is satisfactory to learn that a plant is now being built in South Wales.

"HOW SOUTH WALES COALS ARE ASSISTING SMOKE ABATEMENT."

By THOMAS DIXON

(Representing the Monmouthshire and South Wales
Coal-Owners' Association).

In his "Review of the Smoke Abatement Movement" pp. 5 and 6, of the *Handbook and Guide to the Smoke Abatement Exhibition at the Science Museum, South Kensington, October 1936*, your President declared that: "The Society, after many years of neglect and opposition, is now recognised by all at its worth, and annually receives an invitation from municipal corporations to hold its conferences in their cities or towns."

There will, I am confident, be no dissent from that declaration. The truth of it is further supported by the holding of your 1938 Conference here in Cardiff at the invitation of the Lord Mayor and the City Corporation. At the outset, I am tempted to draw this distinction between the value of the visit of your Society to Cardiff and that of the Conferences you have held from time to time in other large industrial and commercial centres in the United Kingdom. In many of those centres the condition and appearance of the buildings must have visibly emphasized the urgency of the problem of smoke abatement;

but in the City of Cardiff, on the contrary, you are given an impressive illustration of the achievement in a very large measure of the objectives of the Society.

Cardiff's Soot-free Atmosphere.

Those of you whose first visit it is to this City will, I doubt not, have observed with surprise, if not also with some envy, how free the City is from the sooty appearance which is so marked a feature of so many of our large commercial and industrial centres. Many Cardiff buildings, notably those in the City's famous civic centre and in its principal thoroughfares, look almost as fresh and clean to-day as when they were first erected. You may quite pardonably ask why Cardiff possesses this distinction, particularly, bearing in mind the fact that "Cardiff," the City of your Conference, is associated the world over as closely with "Coal" as is "Smoke" with "Abatement" in the title of your Society. Association of ideas inevitably leads us to identify "Smoke" with "Coal", yet here in this City, the commercial centre of the South Wales Coalfield and the largest coal exporting port in the world, we find that association falsified. Comparative records of atmospheric pollution show, writes Mr. J. Greenwood Wilson, the Medical Officer of Health for Cardiff, that this City is one of the cleanest towns in Great Britain. If we ask ourselves why this is so, I suggest the explanation is clear: it is that the coals burnt in the homes and in the offices, business premises and factories of Cardiff, are, almost exclusively, the products of the South Wales Coalfield.

It may be appropriate to bring to your notice also the sunshine records of this City. Owing to the obscuring effect of smoke, the duration of sunshine in such towns as Manchester and Bolton, where a great deal of bituminous coal is burned, is, in the winter months, only about one-half that in outlying country districts. In summer the deficiency of sunshine is less marked, but the intensity is at all times reduced, particularly of the ultra-violet rays, which are now recognised as being so essential to health. In Cardiff, on the other hand, a very different state of affairs is to be found, for the duration of sunshine both in winter and summer is as high as, or even higher than, that in outlying country districts. According to the records of the Meteorological Office, for instance, the average daily duration of sunshine for the six winter months October to March is 1.2 and 1.3 hours, respectively, in Manchester and Bolton, compared with 2.3 hours for the seaside towns of Blackpool, Morecambe and Southport, which have the highest amounts of sunshine of any of the recording stations in Lancashire. For the whole year, the figures are 2.7 and 2.8 hours daily for Manchester and Bolton, against 4.1 hours for Blackpool, Morecambe

and Southport. For Cardiff, the corresponding winter figure is 2.6 hours compared with 2.4, 2.2 and 2.5 hours for Weston-super-Mare, Usk and Bath, which are the nearest country recording stations. For the whole year, the corresponding figures are 4.4 hours for Cardiff, against 4.1, 3.7 and 4.2 hours for Weston-super-Mare, Usk and Bath, respectively.

It is, therefore, a reasonable deduction that one solution of the important work on which your Society is so worthily engaged can be found in the greater use of South Wales coals in large industrial, business and residential centres generally, but especially in the London district, the Home Counties and in the Cities and Towns of the South and West of England. This proposal presents no serious practical difficulty. The required supplies are available in large tonnages and at reasonable prices having regard to qualities not only of smokelessness but also of general heating efficiency.

South Wales Smokeless Coals.

As is well known, South Wales Smokeless Coals, i.e., of the Anthracite, Dry Steam and semi-Bituminous types, have a low volatile content, ranging from 5 to about 16%. It is this characteristic which renders them so valuable an aid in your Society's efforts towards that vitally necessary abatement of the smoke nuisance. They have the further valuable property of a comparatively low sulphur content, to which reference will be made later.

In the cause of the public welfare, there is, then, a strong case for the general use of South Wales coals wherever circumstances make it reasonably feasible.

Extension of Service.

I am to show how South Wales coals are assisting in smoke abatement, and, I may add, how it is proposed to extend and expand that service. In doing so it may be convenient to deal with the subject under three heads, namely :—

- (i) Domestic Heating.
- (ii) Central Heating.
- (iii) Industrial plants of all kinds.

Domestic Heating.

A striking feature in the domestic field is the great and increasing popularity of the independent hot-water boiler, that indispensable feature of the modern house, for which South Wales Anthracite and Dry Steam coals are the ideal fuels. Increasingly large and important quantities are demanded for these appliances. This section of the trade and that relating to

central heating have indeed become so important that a special scheme has been developed by the South Wales Coal Owners, in association with the Distributive Trade, to ensure the availability of constant and ample supplies at reasonable prices. In Greater London the scheme includes the fixation of Retail Prices delivered to any cellar, and in the case of other districts throughout the Country a free-on-rail price to each station.

As regards the domestic open fire—a well-known prolific source of atmospheric pollution—the South Wales Coal Owners have had tests carried out by independent authorities which have demonstrated that South Wales Smokeless coals can be efficiently and smokelessly consumed in almost any type of modern fireplace, and particularly in those primarily designed for coke burning. The tests have further demonstrated that smoke elimination is accompanied by greater radiation efficiency, thus shewing that the desired object of smoke abatement has not been gained at the expense of satisfactory heating.

Active research is also being directed by the South Wales Coal Owners to the improvement of existing, and the development of new, types of closed and semi-closed heating stoves and cookers, for which also South Wales Smokeless coals, by virtue of their natural properties, are a specially suitable fuel. This research, while aiming at improved combustion efficiencies, has, as an important object, the reduction to the minimum of the time and attention required by solid-fuel-burning appliances, while, at the same time, ensuring maximum cleanliness. Success has already been achieved in this direction, thus enabling domestic heat from solid fuel to be “on tap,” as it is already with many coal-fired central heating boilers, at a low fuel cost and with a large saving in the time and attention required.

Central Heating.

Concurrently with improving combustion efficiencies in recent years in the application of automatic stokers to central large industrial boiler plants, great advances have been made in heating boilers of all sizes. In view of the important part played by these appliances in smoke abatement, a brief description of the principles involved may not be out of place.

Gravity-feed and Magazine types of Stokers depend on feeding the fuel by gravity either on to a grate or tuyere which are supplied with air by means of chimney draught or by a small forced-draught fan. The rate of burning is controlled by the air admitted by these means, and either system is usually under thermostatic control: thus, when the water temperature rises or falls, the supply of air is either cut down or increased. The conditions of combustion associated with gravity feed are those which will give smokeless burning, but a non-caking or non-

cohering fuel is essential. This type of apparatus is best served by South Wales coals, such as Anthracite and Dry Steams which have these properties.

The Screw Feed or Retort Stoker originated in the United States of America, and although it had been in general service for many years, it was not until 1931 that it appeared in this Country. At the present time, there are some sixteen firms in the United Kingdom manufacturing screw-feed stokers. This machine again displaces the old-fashioned method of hand firing central heating boilers, which not only gave inefficient results, but undoubtedly gave rise to smoke emission except when smokeless fuels were used. The screw-feed stoker is served by a wide range of fuels, but, though the method of combustion involved is favourable towards smokeless combustion with any type of fuel, South Wales semi-bituminous coals have again demonstrated that optimum smoke-free conditions are achieved by their use. It can be claimed, therefore, that even with appliances which from their very principle are contributing towards smoke abatement, South Wales coals have carried this a step further, and have eliminated smoke emission, in addition to providing a fuel which fulfils the other physical requirements demanded by the appliances.

The number of automatic stokers in operation is rapidly increasing, and their use is having a marked effect in the reduction of smoke emission from large plants heating offices and blocks of flats as well as centrally heated factories. Moreover, it is satisfactory to note that this improvement is being effected, not merely without increasing the cost of fuel and attendance, but actually with positive savings in these expenses. By the means indicated, and with constantly improving combustion efficiencies, together with the more general use of the natural smokeless coals of this district, the hitherto obdurate problem of abating smoke pollution of the atmosphere by domestic and office heating appliances may be brought to a reasonably satisfactory solution.

Industrial Plants.

Dealing next with abatement of smoke pollution from fuel used industrially, and considering separately the larger and smaller industrial plants, we find that the smaller industrial works with coal-fired boiler plants are amongst the principal offenders in respect of excessive smoke emission. The causes are various, and they include the use of unsuitable fuel either as to type or size, unskilled stoking, overloading of boiler plant, lack of adequate chimney draught, and not infrequently other generally unsatisfactory combustion conditions. Happily, with the ready aid of the Combustion Engineers engaged by the Coal Industry, much improvement is being effected amongst this class

of coal consumer. In this field also South Wales coals are rendering aid in reducing smoke emission to an extent hardly feasible with the higher volatile coals. Again other industrial works are showing an increased tendency towards the installation of gas producers which convert the solid to a gaseous fuel which can be piped for use in various parts of their works. This type of fuel is easy to control and, when burned efficiently is absolutely smokeless. A typical example of this trend is to be seen in the Potteries where some twenty gas-fired tunnel kilns are now operating, each replacing approximately four coal-fired kilns, the type so largely responsible, I understand, for the appalling smoke condition in that and other similar districts.

Large industrial works, users of large tonnages of coal are, as may be expected, fully alive to the importance of efficient combustion, and they may be relied upon to select with care the type of fuel likely to give most efficient results, including, of course, smokeless combustion. Thus, generally speaking, the only chimney effluent which "the man in the street" will observe from modern super electric power station stacks is the white vapour from water used to wash sulphur vapours and solid particles from the gaseous products of combustion. The most up-to-date methods of combustion as applied to these large works are improved, however, so far as smoke emission goes, by the use of South Wales coals. Super electric power stations, such as those at Battersea and Fulham, may be mentioned as using considerable tonnages of South Wales coals with advantage.

Reducing Sulphur Emission.

So far this Paper has dealt mainly with the influence of South Wales coals on the reduction of smoke emission. The comparatively low combustible sulphur content of these fuels, however—generally about one-half that of many other coals—is a feature of equal importance when considering means of abating atmospheric pollution. From a greater use then of South Wales coals, there would ensue a substantial reduction in the volume of sulphur products discharged into the atmosphere, with marked advantage to the health of the community, and with a great reduction in damage and injury to buildings and to urban vegetation.

Conclusion.

Thus in the various ways indicated do South Wales coals assist, and can increasingly assist, in the invaluable educative and beneficent work of your Society for the abatement of the nuisance of smoke and of other obnoxious atmospheric pollution associated with coal burning. Much remains to be done before your Society can regard its objects as having been achieved, but

the problem can be seen to be tractable in an increasing degree and, in co-operation with your Society and with all other agencies working to the same end, the South Wales Coal Industry will willingly play its part.

“HOW THE GAS INDUSTRY IN SOUTH WALES IS ASSISTING SMOKE ABATEMENT.”

By W. CLARK JACKSON, M.I.MECH.E., M.INST.GAS.E.

(Engineer and Manager, Neath Gas Department).

In this paper I propose to confine myself to a consideration of what the Gas Industry in South Wales is doing to combat the smoke nuisance with which we unfortunately are so well acquainted, and the detrimental effect of which is fortunately kept well before the public notice by the National Smoke Abatement Society.

This endeavour to arouse public opinion to such an extent as to compel effective laws to be brought into being, and thereby banish smoke for all time from our midst, deserves our whole-hearted support.

To the economist smoke means inefficiency and waste, to the doctor it means illness and death, to the ordinary housewife it means more work and more expense, and to all of us who live in towns it means a definite loss of sunlight, dirtier streets and buildings, and fouler air.

As late as June of this year, the Duke of Kent, when inaugurating a huge gasholder erected by the Sheffield Gas Company, stated that the question of smoke abatement was one of far too great importance and far-reaching to be dealt with in a few words, but he was sure that by their developments in the last few years the Sheffield Gas Company had made a material contribution to the elimination of the smoke evil.

Like the great Gas Industry in other parts of the Country, including Sheffield, we, in South Wales have been making rapid strides not only towards the solving of smoke nuisance from domestic chimneys, but also towards the solving of the smoke nuisance from factories and works.

The total output of gas by the South Wales Gas Undertakings during the past year was over 7,000 million cubic feet, of which nearly 15% was made use of for industrial purposes.

The tonnage of coal carbonized by the Gas Undertakings to produce this 7,000 million cubic feet of gas was over 300,000 tons, from which in addition some 100,000 tons of smokeless fuel in the form of Gas Coke was produced.

In this respect it is interesting to note that the carbonization of this tonnage of coal at Gas Works, and the use of it in a smokeless form, saved Wales from a sootfall of nearly 50,000 tons during the year.

Domestic Uses.

Dealing first with the domestic chimney, and which is still by far the greatest culprit in causing smoke nuisance, the South Wales Gas Industry has during the past five years been working on a definite plan of campaign to improve the service which gas can give to the housewife as an economical, convenient and smokeless fuel, with very marked success.

As an alternative to the old kitchen range, the gas cooker has always been in demand, even although it was—up to some few years ago—far from being a thing of beauty, and its cost much too great for the average working-class householder, by our co-operative efforts, working in conjunction with the gas cooker manufacturers, gas cookers have now been developed and designed with modern streamline effect, built so as to take up the least possible amount of room, and finished in gleaming enamel finishes of various attractive colours.

In addition the burners on these cookers have been improved out of all recognition, and the oven fitted with automatic heat controlling device which has the effect of enabling cooking to be done without the housewife having to stand by adjusting taps, and which in addition means a saving in gas consumption to the housewife of at least 15%.

Coincident with this step taken to improve the design and efficiency of gas cookers, a marketing scheme was devised whereby these cookers could be purchased at extremely low, long term, hire purchase prices, and these two factors together, have resulted in a tremendous increase in the number of gas cookers used in the working-class houses of the district, until at the present time there are well over 250,000 gas cookers in use out of a total of 310,000 actual gas consumers.

There are still far too many houses without gas cookers, but this number is being rapidly reduced; the effect of this large number of cookers on the atmosphere in preventing smoke, particularly during the summer months, is most marked.

Whilst the chimneys of rooms used for occasional purposes and bedrooms cannot probably be classed in the same category as kitchen chimneys as producers of large quantities of smoke, their ill effects cannot be overlooked, and in this direction gas fires have proved of very great benefit.

Here again the sales policy of our Industry has been highly developed, and has included the modernising of designs, increased

efficiency of the fire itself, and a selling policy based upon easy long term hire purchase.

As a result, sales of gas fires are increasing by leaps and bounds, and at the present moment over 50,000 gas fires have been installed.

Wash Boilers.

Another chimney producing smoke which has often been overlooked is that one connected with the old wash copper, and which usually on Monday mornings used to belch out its smoke from practically every house in the towns and villages of the district. The advent of the Gas Wash Boiler and the rather wonderful manner in which it has been taken up by the public generally is rapidly doing away with the old fashioned copper and the smoke which it produced.

Here again the sales policy of our Industry has been equally well developed, including as it has done the design of these boilers on modern clean cut lines, finished in gleaming enamel, with nickel draw-off water taps, an improved type of burner, many of which are of the self lighting design, and a selling policy again based upon easy long term hire purchase.

During the past five years tens of thousands of these boilers have been sold and fixed in the South Wales district, in fact so great has been the number that most Gas Undertakings now find that the Monday morning consumption of gas, owing to these Gas Boilers being in use, is equal—and in some cases even greater—than what used to be the highest peak load of the whole week, namely, the Sunday forenoon cooking load.

So much has this improved Gas Service been appreciated by housewives generally that a further call has now come from them for the Industry to produce suitable appliances capable of providing the necessary hot water for baths and domestic purposes.

To meet this demand our Industry has for the past twelve months, through its Industrial Centre attached to the Cardiff Gas Light & Coke Company, tested out numerous types of heaters and has now decided upon two types, both highly efficient, and also a sales policy which will enable them to be placed at the disposal of householders generally at a cost of only a penny per day—less than the price of a box of Vesta matches.

In passing it is of interest to note that one of these heaters is built upon the patent design of a Cardiffian, and is being produced by a factory in Cardiff specially equipped for this purpose.

In addition to the foregoing policy, and which has for its purpose the placing of suitable appliances at the disposal of housewives for cooking, space heating and water heating, using

our efficient and economical smokeless fuel—Gas, our Industry has also given very serious and careful consideration to the question of the promotion of special price tariffs for gas itself so as to enable the public to take still further advantage of our smokeless fuel, more particularly for space heating and water heating, and although at present only a few Undertakings have put these promotional price tariffs into operation, very careful note is being taken by the other Undertakings as to the results obtained, and I have no doubt but what in the very near future promotional tariffs will be adopted by the majority, if not by the whole of the Undertakings forming our Industry.

That the general policy of our Industry has met with the approval of the public is proved by the fact that in the domestic field increases in gas consumption varying from 5% to 15% have been recorded by the various gas Undertakings, and in one outstanding case, namely, Port Talbot, an increased consumption for domestic purposes of 40% has been recorded over a period of 3 years.

Notwithstanding, however, all this rather wonderful achievement there still remains a very large field to be covered and still a very great amount of educational work to be carried out.

New Houses.

In this connection I would point out that in spite of all the educational work carried out by the National Smoke Abatement Society, in spite of all the reports put forward year by year by Medical Officers of Health, and in spite of the considerable damage caused to the community by smoke, municipal housing sites at this very moment are being erected throughout the length and breadth of the South Wales district where the houses are equipped with grates and ovens only suitable for raw coal, and of grate designs incapable of burning this raw coal without smoke being given off in large quantities.

Cases have even been brought to my attention where the local authority has refused permission, or at least put very substantial obstacles in the way of allowing their tenants to have gas cookers, gas wash boilers and gas fires installed.

Surely the time has arrived when the Ministry of Health itself ought to step in even to the extent of withholding permission to proceed with these houses, badly needed as they are, unless the local authority is prepared to take advantage of a heating service, which is not only of advantage in providing heat without smoke, but also providing this service at an economic price to the tenant coincident with a very great saving in labour and arduous toil to the housewife herself.

I can only hope that meetings such as these together with the general publicity work already carried out by the National

Smoke Abatement Society will bring about a real change, and that local authorities in any case will lead the way in bringing about a smokeless South Wales by seeing that all future housing sites are provided with grates equipped for burning smokeless fuel.

Gas Coke.

This brings me to the alternative smokeless fuel which the South Wales Gas Industry has for disposal, namely, coke.

Coke has been the principle by-product of the Gas Industry since the Industry began, and whilst it was used extensively in the past for certain industrial and semi-industrial purposes, it is only within the past few years that a real concerted effort has been made by our Industry to capture the domestic heating business.

Coke as it was produced in the past was always capable of being used in a certain type of domestic grate, but generally speaking it had certain inherent limitations for this purpose.

Thanks to the excellent work done by the London and Counties Coke Association together with the London group of Gas Undertakings, the quality of coke itself has been very considerably improved.

It has also been broken down and cut into correct graded sizes for the domestic market; incidentally this cutting and grading eliminates most of the ash; and fire grates of a really efficient design have been evolved, these fire grates during the past few years having in addition been fitted with a specially-shaped gas burner for quick lighting of the coke itself, thereby doing away with the old method of having to use paper and sticks.

Our Gas Industry in South Wales readily saw the great advantage to be gained by adopting these specially designed coke fire grates as well as the necessity for correctly blending gas coals to obtain the best type of gas coke suitable for these grates, and installed cutting and grading plant to produce the correct sized grades for this market.

A large number of our members are now producing really first-class coke well suited for the domestic market, and are marketing this coke in the necessary sized grades as required.

As a result there has been a very marked increase in the use of coke for domestic fires in the South Wales district, and already many works, where previously a large portion of the coke produced had to be exported, are now finding that the local domestic market is taking up practically all their output.

These coke fire grates are very economical in use, give a very pleasing effect—a most important point—and so far as heat is concerned are highly efficient.

There is nothing experimental about these fires as they have given every satisfaction to those who have installed them during the past few years, and it is this type of fire in my opinion that local authorities ought to adopt in their future housing sites.

As far back as 1921 Lord Newton's Committee made the following recommendations :—

“That the Central Housing Authority should decline to sanction any housing scheme submitted by a local authority or public utility society unless specific provision is made in the plans for the adoption of smokeless methods of supplying the required heat. The only exception to this rule should be when the Central Authority are fully satisfied that the adoption of such methods is impracticable.”

As I have previously mentioned there is hardly a housing scheme at the present time where open coal fires in some form or another are still being constructed, simply perpetuating old Victorian heating arrangements.

It is to be noted, however, that there are some notable exceptions. In Leeds, for instance, the Corporation gives the tenants every encouragement to use smokeless solid fuel in the range in place of coal. Sassoon House, in South London, is a completely smokeless block of working-class flats, coke being used for living room fires, and the latest and perhaps one of the best examples is Kensal House, recently built by the Gas Light & Coke Company to demonstrate that smokeless work-saving dwellings can be run at a lower cost for fuel than the average working-class family has to pay for an old-fashioned and smoke producing fuel system.

In this case also coke fires, ignited by gas, are used for warming the living rooms, whilst gas is used for cooking and hot water. It is pleasing to note that the experiment has been highly successful.

The weekly fuel bill of the average London working-class family is about 6/-, whilst the weekly fuel bill of the average Kensal House family is 4/4d.

For the advocates of smoke abatement the importance of these facts is obvious and justify the contention of our Industry that we can supply the whole of the domestic heat requirements with a clean, efficient and economical fuel, either in the form of gas or coke.

It is with this goal in view that our sales policy has been developed, and so far with such success.

Industrial Uses.

I shall now deal with what our Industry has been able to do so far, and is endeavouring to further extend, in the matter of preventing smoke by means of an efficient and economical smoke-

less fuel in the many Works and Industries situated in South Wales.

In the first place I need hardly remind you again that whereas the domestic chimney is the greatest producer of smoke in the aggregate, in certain of our South Wales towns, where Industry is concentrated within the towns themselves, the smoke emission from the Works is simply dreadful and has really to be seen to be believed.

A number of those present will, like myself, be acquainted with towns where the tinplate works constitute the staple industry and where the amount of smoke at times—not as some would imagine from the boiler houses chimney—but from the coal fired tinpots and more particularly the coal fired mill furnaces and annealing furnaces, is simply appalling.

The Welsh Tinplate Industry has been somewhat slow in adopting modern practice so far as heat requirements are concerned, and unlike American practice where for many years gas has been utilized for practically every heat requirements of the Tinplate Works.

During recent years, however, a decided movement to follow American practice has been seen, and a number of Tinplate Works have adopted gas for their heat requirements, although this has been mostly in the form of producer gas.

The latest plant, however, now nearing completion at Ebbw Vale will use Coke Oven Gas produced from the Coke Oven Plant built as an integral part of the combined steel and tinplate works.

The South Wales Gas Industry has helped considerably in this change over, and under the auspices of the Cardiff Industrial Centre, to which most of the Undertakings belong, a considerable amount of experimental work has been carried out during the past few years, as a result of which the Town Gas is now being used for very many purposes, including the heating of tinpots, scruff furnaces and the firing of annealing furnaces.

Our Industrial Centre has also carried out experimental work in many other directions, and has thereby been of considerable advantage to Industry generally.

A brief summary of the various types of works now using Town Gas for heating purposes in place of raw coal—with a resultant benefit to the community in the form of smoke prevention—might be of some little interest. It is also particularly interesting to note that practically every new works which has been put down in Wales during the past few years have adopted Town Gas for their heat requirements.

At Aberdare, Messrs. Aberdare Cables, Limited, are making extensive use of gas for melting lead.

At Cardiff, gas is being extensively used for the heating of

billetts, galvanizing processes, annealing and case hardening, and in the lighter trades, it is being used extensively for central heating, pasteurizing and sterilizing of milk, etc.

It is also used extensively in the bakery and confectionery business, and in the newspaper and printing world in connection with large scale type plate making.

At Neath the Metal Box Company at their new Factory use gas entirely for their heating requirements and have entered into a 10-year contract with the Neath Corporation Gas Department.

At Newport, gas is being used for "Blueing" Studs for use in the Boot and Shoe Trade, for the melting of pitch and for Bright Annealing of Strip.

At Pontypool, a new Glass Works use gas for the whole of their laboratory purposes, and a new Biscuit Works at Llantarnam use ovens which are entirely heated by Town Gas.

At the Treforest Trading Estate, Pontypridd, gas is being used extensively in the following factories:— Phillips Bros., Printers—for their 5-cwt. Melting Pot and Monotype Casting Machine.

Davies Steel Specialities—for their Hardening Furnaces, Tempering Furnaces, and Drier.

K. Stainer & Co. Ltd.—for their Furnace.

Coupe & Tidman, Ltd.—for their Muffle Furnace.

Treforest Moulding Co. Ltd.—for their lead melting pots.

The other Works on this Estate also use Town Gas for some purpose or another.

At Swansea a new Factory at Landore is using gas extensively for furnace work, and at another Works gas is being used for chain annealing purposes.

In addition to these uses, a very large number of gas-fired central heating installations have been installed, and although this use does not to any extent displace raw coal, as most central heating installations have in the past either used coke or anthracite, it does show how gas service is being appreciated for its cleanliness and efficiency.

The one serious draw back to the further extended use of Town Gas is displacing raw coal, and thereby bringing about a further improvement in the smoke conditions of the district, is that of price.

The experimental and educational work which has been carried out by our Industry has—I have every reason to believe—convinced practically every Industrialist that for heat treatment of metal and the heat requirements of Industry generally, Town Gas gives better results than can be obtained from raw coal.

This has been proved over and over again, but more particularly in Sheffield where the output of gas within the last

20 years has risen from 5,000 million cubic feet per annum to 10,000 million cubic feet last year, practically the whole of this increase being brought about by Industrial users of gas.

Unfortunately, unlike Sheffield, our Industry in South Wales is unable to draw to any great extent upon Coke Ovens for surplus gas, the fact being that the surplus gas available from Coke Ovens in our district is only of a very limited amount.

If it were possible for a gas grid to be laid down to serve the South Wales District in the same manner as the South Yorkshire Gas Grid serves South Yorkshire, and into which Gas Grid the very many large Coke Oven Undertakings deliver their surplus gas for resale by the Gas Undertakings at extraordinarily low prices, I have no doubt but what we should see the same change over from raw coal to gas in our district as has taken place in and around Sheffield, with a very marked decrease in the smoke pollution of the district as a result.

Unfortunately these conditions do not exist, and we are therefore unable to compete on a price basis against raw coal in major heating operations, although as I have already mentioned, in most of the minor heating operations Town Gas is already greatly favoured and has definitely played some considerable part in reducing smoke emission in our district.

I have endeavoured to set out in this paper in simple understandable terms and without any great technical detail the admirable work which the South Wales Gas Industry is carrying out on behalf of smoke prevention and the excellent results which so far have followed upon the policy as set up by the Industry during the past few years.

I am naturally aware that there are other Industries and many other agencies whose work during these past few years has also resulted in the reduction of smoke emission, and papers dealing with their efforts are being read before this Conference.

I would regret therefore if the contents of my paper were misconstrued in any shape or form, as even with the concerted efforts of the whole lot of us we are still a very great way off from the goal which the National Smoke Abatement Society stands for, namely, a smokeless, and therefore a healthier Britain.

"ELECTRICITY IN SOUTH WALES"

By JAMES SMITH, B.SC., A.M.I.E.E., M.A.M.E.E.

Future historians will probably record among many other events that the early part of the 20th century was a period of rapid electrical development from a pioneering stage to extensive generation, transmission and use of that service and the author is led to hope that the same historians will also record that during the same period by reason of the activities of the National

Smoke Abatement Society and of those industries concerned with the supply of smokeless fuels, gas and electricity, the emission of large quantities of smoke into the atmosphere ceased with consequent reversion to conditions of natural cleanliness.

It is perhaps unnecessary to stress in a paper to be presented to members of the National Smoke Abatement Society the part which electricity has played and is playing in aiding the efforts of the Society to abate smoke, as this pleasing feature of electricity is well known.

Over the past 40 years electricity has passed from its pioneering stage to a service well tried and widely adopted by the community and there is little evidence to indicate that the present rapid rate of development is decreasing.

Records are available to all those interested in the very comprehensive statistical returns of the Electricity Commissioners and year after year gives proof of the ever-increasing use of electricity and the widening of the scope for its use.

Electricity is essentially a form of energy which with modern technique can readily and efficiently be generated, transmitted and used. It is proving a convenient form of energy in that it can readily be translated into light, heat and power, again with high efficiency. It is therefore perhaps not surprising that it is being adopted increasingly to meet the requirements of mankind in these services so essential to modern life.

The development of electricity supply in South Wales has kept pace with that over the whole country and it is not unnatural that electricity supply in South Wales presents features which are a reflection of the extensive requirements of that area for these services of heat, light and power.

South Wales is essentially an industrial area due primarily to the existence of an extensive series of coal measures underlying most of the area, and also to the fact that most of South Wales is covered by steep, rather barren hills and valleys, which have rendered agriculture unprofitable.

Certain coastal areas such as the Vale of Glamorgan and the Gower Peninsula are agricultural in character as is an area along the valley of the river Usk, but over most of the county of Glamorgan and parts of the counties of Monmouthshire and Carmarthenshire mining of coal is the chief activity.

Industry in South Wales.

It will perhaps be advisable at this stage of this Paper to define what is meant for the purpose of the Paper by the expression "South Wales." The term will have widely differing meanings depending whether the view point be geographical, geological, industrial or national. In this Paper the author is concerned with the major features of electricity supply and these are a reflection

directly or indirectly of the industrial activities of the community and therefore it is the area of industrial activity which is referred to by the author in that well used term "South Wales."

To the north, east and west of the coalfield the character of the area changes abruptly to that of the agricultural counties of Brecknock, Hereford and Carmarthen, while to the south of the coalfield lies the Bristol Channel with its coastal belt of industrial activity extending from Newport to Llanelly.

The coal mines are in general located in the valleys and the housing of those concerned with that industry and those dependent on that industry has by reason of water and drainage requirements necessarily been confined to the bottoms of the valleys and to large towns located at the junctions of important valleys.

Between the valleys are extensive ranges of mountains sparsely populated and much of the area of South Wales is completely barren from the point of view of electricity supply.

Apart therefore from the coastal area the industrial area of South Wales consists chiefly of narrow belts of intense activity separated by areas almost completely void of activity either industrial or agricultural. These features reflect exactly in the electrical characteristics of the area and concentrations of large industrial and public service demands have to be catered for by transmission lines which pass for much of their lengths through barren territory.

The area is not an easy one for transmission of electricity as the sides of the valleys are in general steep and the mountain tops very inaccessible and exposed to frequent high velocity winds and occasional heavy sleet storms. In the valleys, particularly in certain areas subsidence due to mining activity occurs and most careful maintenance is necessary on high tension cable work laid in the streets of such valleys. Engineering technique has however prevailed against these difficulties and throughout the area reliable services of electricity are available.

Along the coast line rapid development of housing has taken place particularly at the ports and the coastal towns are all from an electrical viewpoint of substantial size and importance.

The Iron and Steel industry is an important one in South Wales and in recent years this industry has tended to be located near the principal shipping ports and with one or two rather notable exceptions the principal blast furnaces, steelworks and tinplate works are located along the coast line leaving the hinterland of South Wales Valleys almost wholly concerned with the winning of coal.

New Industries.

This feature in times of depression of the coal trade has led

to widespread unemployment and considerable effort has been directed in the last few years to the establishment of new types of industry in South Wales and as a result there is now at Treforest, about midway between Cardiff and the Rhondda Valley a large trading estate on which there are already established works concerned with the production of paper, chrome leather, carbo-ice, chemicals and other varied products. Under the same scheme there have been established in other parts of the area works concerned with the manufacture of cables, glass, biscuits, engineering valves, clothing and machine parts. This diversity of types of industry should assist materially in maintaining a reasonable level of prosperity of the community in the area in the event of a renewed depression in the coal industry.

It may be of interest to note that the extensive Trading Estate at Treforest is served with electricity and steam from the South Wales Electric Power Company's Generating Station at Treforest and none of the tenant factories on that estate are equipped with chimney stacks. The estate is therefore completely free from smoke and grit. The layout of the estate and the styles of construction of the various works have received the attention of eminent architects and the general effect of the estate when completed should be a very pleasing one which we may hope will be indicative of future conditions.

The principal industries of South Wales are of a type which require large quantities of power and if South Wales be regarded as a whole it would be true to say that the trend of electricity supply has been to make available large quantities of electricity at comparatively low rates to industrial consumers in addition to the important supplies of electricity required for domestic and other public services.

The larger coastal towns such as Newport, Cardiff and Swansea are served electrically by the respective Municipal Electricity Departments and in each of these towns there is a generating station connected to the Central Electricity Board's transmission lines, the generating station of the Swansea Corporation at Tir John being quite recent in construction and embodying most modern features.

The supply of electricity for domestic and public service over the remainder of the area is partly handled by local authorities and partly by the South Wales Power Co., who incidentally supply most of such local authorities in bulk from their large selected station connected to the Grid near Treforest.

The area is served as regards industrial power supplies by the South Wales Electric Power Co., and by the Llanelly and District Electric Supply Co., the industrial needs of some of the

principal coastal towns being served by the municipal authorities concerned.

The Central Electricity Board's lines traverse the area in an east to west direction, the lines connecting the Newport, Cardiff, Treforest, Swansea and Llanelly Power Stations.

The area to the west of the Llŵchwr river is served by the transmission lines of the Llanelly Company, the remainder of the area being served by the transmission lines of the South Wales Electric Power Company.

It is a natural reflection of the character of the area that of the output of the South Wales Electric Power Company by far the larger proportion is destined for industrial use, very large quantities indeed being required by the collieries, steelworks and tinplate works connected to the Power Company's transmission system.

There are a number of important private industrial generating stations in the area but these are steadily becoming fewer in number and there is a general tendency to derive electricity from the authorized suppliers which in itself in an area where cheap fuel exists and waste heat is available is evidence that reliable and satisfactory services of electricity are generally available throughout the area at economic charges.

Domestic Uses.

The author anticipates it will become apparent at this Conference that South Wales is in general comparatively free of the smoke nuisance no doubt due to a considerable extent to the type of coal available in this area for domestic and factory use. The smoke emitted from domestic chimneys in South Wales usually takes the appearance of a light blue haze and there is little of that oily-looking thick black smoke which is a feature of less fortunate areas in this country. With the rapid development of the use of electricity for domestic service the amount of such existing smoke is decreasing and over large sections of the area the number of houses which are all electrically operated, particularly in the summer months, is rapidly increasing.

Electricity is available at economical rates for cooking and water heating and for those occasional fires which are required in the summer months with the result that during such periods no smoke whatsoever is emitted from the chimneys of houses equipped in this way. At present, in the winter months coal is extensively used for domestic heating but gradually the burning of raw coal is giving way to the use of coke, gas or electricity.

The collieries themselves cannot be said to be producers of smoke in large quantities and there are a number of collieries which are all electrically operated with the result that no fuel

whatsoever is consumed at the colliery and no smoke produced. Colliery companies are steadily developing the use of power both for underground purposes and for the surface machinery and electricity is proving the most economical and convenient form of energy for these requirements; with the result that colliery boiler plants are gradually being eliminated and the clean all-electric drive substituted.

Steelworks produce much of their heating requirements in the form of blast furnace and coke oven gas and this feature in conjunction with a practically universal adoption of electric drive has undoubtedly reduced to a very large extent the burning of raw coal at such works and the amount of smoke emitted. There are several electric furnaces in the area each of which undoubtedly has played its part in reducing the quantity of smoke emitted.

The Power Stations.

The question may be asked, whether in producing electricity, Power Stations do not themselves produce smoke and in reply to such a question the author can without hesitation state that at least as far as the South Wales area is concerned Power Station chimneys are not guilty. Power Stations are in general remote from zones of housing while the character of the coal used and the technique adopted for its combustion are such that anything corresponding to dense black smoke is not produced and at the worse there is discharged but a light blue haze.

Power Station engineers have devoted much expenditure and effort to ensure that they shall not be guilty of producing undesirable and unnecessary smoke and to this end a Committee was appointed by the Electricity Commissioners which made a survey of modern practice in this and other countries to prevent the emission of smoke and their reports and findings have been published for the benefit of those concerned. It is interesting to note from that Committee's report that the electro-static type dust extraction plant is proving very successful and compares favourably with other types of such plant particularly as regards cost of operation.

The products of combustion are made to pass through a chamber fitted with pipes or plates which act as collector electrodes. In the centre of the pipes or between the plates are mounted discharge electrodes insulated from the apparatus and maintained at a high negative potential which may be up to 100,000 volts for certain classes of precipitation.

Solid particles in the gases become electrically charged and these move towards the positive collector electrodes and give up their charge to those electrodes. It is arranged that the discharged particles fall by gravity into hoppers and arrangements

are sometimes incorporated to vibrate the collector electrodes to remove masses of particles which adhere to them.

Here therefore is a practical instance of how electricity can directly be used to maintain a chimney discharge free from smoke particles and grits and it may therefore be claimed that while the use of electricity obviates the production of smoke its adaptability is such that it can also be used to cleanse smoke to a degree which renders it innocuous.

Charges.

Discussions on electricity supply matters usually give rise to questions relating to charges for such supply and a brief examination of the factors governing such charges may be of interest.

The factors governing the price at which electric service can be given to the community are in no way difficult or special in character and such prices must depend on the nature of the territory when viewed from an electrical standpoint and the extent and character of use which the community makes of the services of the electricity supply authorities.

It is obviously difficult to supply electricity throughout very sparsely populated areas at attractive rates when the only use made of the service given is that of lighting in the winter months. Capital charges on equipment form the chief component of electricity costs and these charges remain more or less constant whether much or little use is made of the service available. It follows that electricity development has therefore a snowball effect in that the greater the use made of electrical services the lower can be the charges for such services, which in turn attracts more consumers and leads to a greater use for existing and new purposes by the existing consumers.

Electricity charges in many parts of the country including South Wales have now reached a level where the all-electric house is both practical and economical and there can be no doubt the all-electric house will be a feature of the future.

Electricity has been almost universally adopted by industry for lighting and for power drives and is being increasingly used for industrial heating and the all-electric mine or works will in the future be even more common than to-day.

When this desirable state of affairs is reached the problem of smoke abatement will undoubtedly be much less difficult than at present and the efforts of the Smoke Abatement Society will have prevailed.

LOW TEMPERATURE CARBONIZATION IN SOUTH WALES.

By Col. W. A. BRISTOW, M.I.E.E., F.R.A.C.S.

The main object of the low temperature carbonization of coal is the production of a smokeless solid fuel which is suitable for general domestic heating and especially for the open fire.

Up to the present, most of the smokeless fuel of this type sold in the United Kingdom has been produced at three works in Derbyshire and Yorkshire and in one at Greenwich. The erection of a fifth plant in South Wales was decided on as the logical way of meeting the increasing demand for the fuel in West and South-West England. The rapid growth in the exports both of smokeless fuel and of the liquid by-products of the process also made South Wales a desirable site for the new plant.

The carbonizing plant itself is now nearing completion at Pencoed, Glamorgan. It will carbonize practically the whole output of the adjoining colliery, Wern Tarw, where the coal though not suitable for domestic use in the raw state, is of an excellent type for treatment by low temperature carbonization and produces a very good grade of smokeless fuel.

During the past ten years, we have seen great developments in this country in the scientific utilization of coal. We can fairly rank the low temperature carbonization process as being one of the most important of these developments and it has the distinction of being the only completely British process of the kind for its inception and successful development have been carried out entirely by British engineers. By this process coal is distilled at temperatures of 500/600° C., about half those employed in high-temperature carbonization, and this reduction in temperature results in a complete change in the quantity and composition of the resultant products. The main product, as I have stated, is a solid smokeless fuel, 14 cwts. of which are obtained from every ton of coal treated. This smokeless fuel is unique in radiation efficiency, and it has become highly popular with those who wish to retain the open coal fire with all its advantages, but who wish also to eliminate smoke and soot from their homes and the atmosphere.

In describing the rise of low temperature carbonization, it is not my purpose here to underrate in any way that increasing "smoke-consciousness" on the part of the public, which, as much as anything else, enabled a successful low temperature carbonization industry to be built up. It was the undoubted fact that a large section of the public were already determined to heat their homes smokelessly which sustained our industry in its early days, when it had no energy to spare for making converts.

There has, in fact, been a revolution in social habits which is none the less important because it has come upon us almost unperceived. The hermetically sealed, black-horsehair-filled home

and drab clothes of Victorian days necessarily coincided with an era when smoke spelt prosperity. Since then, and almost entirely since the war, the people have begun to demand the return of their old birthright of clear skies and fresh air. Ease of travel for the masses, perhaps, has induced them to rebel against the smoke-laden air in which most of them have not only to earn but eat their bread. Hence the popularity of the gas and electric cooker, and the gas and electric fire, and hence, too, some of the difficulties in which the coal trade now finds itself.

Where short-time, intermittent heating is required, the gas and electric fire are satisfactory enough. But in our climate, grey skies and a moisture-laden atmosphere are the common lot. Hence, if a fair standard of comfort is to be maintained, one room even in the poorest home must be heated all day for the greater part of the year. The open coal fire, round which all the family can gather in comfort at night, and which can perform a dozen services during the day, is thus still the choice of the majority, not only on grounds of cost. Subconsciously, the cheerfulness of the open fire weighs a good deal, and the better ventilation and healthier atmosphere induced by it are also realized, if only by force of contrast. Great as the forces of reform are, therefore, we still must not underestimate the strength of the position held by the open coal fire. The replacement of ordinary coal by smokeless solid fuel is not only the simplest method of smoke abatement but, in the case of low temperature process fuel there are certain other unexpected benefits. This fuel has a radiation efficiency considerably higher than that of coal—the gain being sometimes as much as 50%; it burns up rapidly, thereby enabling a cold room to be made habitable quickly, yet due to its light weight the rate of consumption is by no means excessive. It is usually found that a ton of the fuel is equivalent to about 30 cwts. of ordinary coal.

Particularly important, however, is the nature of the radiant heat emitted by this fuel when burning. Now, radiant heat may be obtained by a variety of means, though the nature and extent of the radiation will vary considerably according to its source. Though low temperature carbonization fuel has high radiation efficiency the warmth is of a particularly penetrating kind, which can be borne in comfort, without scorching the skin. In part, this is due to the fact that such a fire emits an appreciable quantity of infra-red rays coming from that portion of the spectrum immediately next the visible octave. These rays have the power of warming the tissues below the skin and their beneficial and stimulating effect is now well understood.

Important as such considerations are, it should be appreciated that low temperature smokeless fuel has won its way, in the main, by offering a combination of convenience and economy, not obtainable in any other way. It has been available in commercial quan-

tities consistently only since 1927, yet by last year the output had increased over tenfold, while the future rate of expensive promises to be even more rapid. The bulk of the supplies up to now have come from the plants at Barugh, Barnsley and Bolsover which have been working 24 hours a day, 365 days a year. This is a very commendable record, because the operation of a low temperature carbonization plant is by no means free from technical problems of a peculiar and exacting kind.

The low temperature carbonization plant in South Wales, however, will have the benefit of the experience already gained during the past decade, and I think the industry has before it in Wales a long and valuable career. Certainly it is commencing under conditions more favourable than those which attended the inception of any of the plants now existing. There is for one thing, an adjacent market which up to now has had to draw its supplies of low temperature fuel from a distant source in spite of the extra transport cost. But, in future, Wales and all the Western and South-Western Counties, including such large centres of population as Bristol, Bath, Cheltenham, Worcester, Gloucester, Oxford, Southampton, Bournemouth and other towns, will have a source of supply almost next door to them, in Glamorgan.

The collieries at Wern Tarw will supply the coal for treatment, and, since last year when they were purchased by the sponsors of the South Wales plant, they have been undergoing an extensive modernization. When the whole plant is at work, two very good results will have been achieved—a large new supply of smokeless fuel will have been made available, and new trade will be brought to an area which badly needs it.

The process of low temperature carbonization which will be employed is briefly as follows: After being brought to the surface at the adjoining colliery, the coal is washed free from dirt and shale, before being loaded into trucks, which gravitate down the few hundred yards which separate the colliery from the works. For record purposes all coal reaching the works is weighed by a combined weighbridge and wagon tippler. At this stage samples are taken for analysis so that a constant check may be kept on the ash content, which should average not more than 4%. Below the wagon tippler is a hopper from which the coal is fed on to a belt conveyor which, running upwards, delivers the coal into the storage bunkers. These reinforced concrete bunkers, are divided in 19 sections, stand 72 feet high and hold, in all, 3,000 tons of coal. To allow the surplus water to drain off, the coal remains here for at least 48 hours. On reaching the top of the storage bunkers, the coal is stored in separate sections according to the seam from which it has come. This is a matter of the utmost importance for it facilitates accuracy of blending and ensures the uniformity of the coal. The actual blending of the

coal from the different bunkers is done by means of variable speed travelling conveyors situated at the bottom of the bunkers. These conveyors discharge on to a main blending belt and by their use it is possible to obtain any desired blend of coal merely by varying the speed at which the conveyors operate. At this stage samples are again taken in order to ensure that the blend is such as will result in a uniform smokeless fuel of the standard quality. From the main blending belt the coal is taken to the crushing house where, if necessary, it is reduced to the most convenient size. As a rule this stage is not required as the coal is usually sufficiently small but it provides another safeguard for the uniformity of the material. Normally then the blended coal is carried by means of elevators to bunkers above the carbonizing plant. There is one bunker for each battery of retorts, and each bunker holds 24 hours' supply of coal. The 36 retorts in each battery are arranged in two rows of 18. They are worked in pairs, being charged two at a time by means of a travelling coal skip. This skip, which is filled from the overhead bunker, holds an exact charge for a pair of retorts which are approximately 9 ft. long. The tubes of the retorts are tapered, being larger towards the bottom so as to facilitate discharge and while one charge is being carbonized the previous charge is held in a steel cooling chamber arranged immediately below each pair of retorts. This arrangement permits the smokeless fuel to be cooled in the dry state. To produce a smokeless fuel of satisfactory strength and reactivity, the coal must be carbonized at 600°C ., and in order to ensure uniformity it is essential that this temperature should not vary. For this purpose a constant check is kept on the retort temperatures by means of pyrometers; accurate temperature control is of considerable importance as it ensures production of fuel with a standard volatile content. On this depends the ease of lighting and the satisfactory burning of the fuel. The partially-cooled smokeless fuel is then screened and freed from dust and breeze, before being loaded into wagons for despatch.

The coal reserves at the South Wales plant are sufficient to provide for the industry's operations, even on an increasing scale, for many years. Further extensive areas of suitable coal were recently reserved for low temperature carbonization, however, and consequently development on the largest possible scale can now take place without any lack of suitable coal for processing. We can hope that as a result, the number of smoking chimneys in the West of England will shortly be drastically reduced, even though the number of open firms may remain the same.

Those of you who are acquainted with the "parsimoniousness" of modern industry will not be surprised to hear that besides a smokeless coal, the low temperature process yields a long list of valuable secondary products. Like the Chicago pork-packers, there is a very little material we can't put to some use. First and

foremost, of course, comes the solid fuel and from every ton of bituminous coal processed, 14 cwt. of this excellent smokeless fuel are obtained, as well as three gallons of the highest-grade petrol. But by way of a bonus there also remain 18 gallons of coal oil, and a considerable quantity of "rich gas" of high calorific value, and from the secondary products we can obtain a lengthy range of other products, varied as the state of the market suggests. First it is possible to obtain a little more petrol, and a large quantity of Diesel engine fuel by subjecting this 18 gallons to a further distillation. Or, if we wish, we can arrange for the whole of these 18 gallons to be treated by the hydrogenation process and so convert them into an equal volume of petrol or Diesel oil. Again, after the removal of the pitch content, the higher boiling portion of these 18 gallons can be marketed as creosote, for wood preservation. It is, in fact, very efficient for this purpose, and several railway companies have contracted to take large supplies of low temperature creosote for the treatment of sleepers, etc. By the distillation and washing of the oil we recover a pitch, and several grades of what are known as tar acids. In one form these acids make their appearance in your homes as a disinfectant, while others finish their career in copper mines all over the world. Here they are used as frothing or flotation agents in the production of copper. There are, of course, many other uses for these tar acids, based as a rule on their antiseptic and germicidal properties. Thus, they are in great demand as sheep and cattle dips; such countries, as Argentina, Uruguay, South Africa, Australia and New Zealand use them in this form in very large quantities every year. Sprays employed for the prevention of disease and pest destruction in both orchards and rubber plantations usually contain a considerable quantity of tar acids.

The plastics industry is another large consumer, for the tar acids are one of the raw materials in the manufacture of synthetic resins of the phenol-formaldehyde or Bakelite type. Dyestuffs, explosives and a wide range of chemicals are also obtainable by further treatment of these acids.

The rich gas I mentioned is at present utilized in the plants themselves, but there is no reason why, in course of time, it should not be distributed by a sort of gas grid among the neighbouring towns and villages. Each and every one of these products has been removed from the raw coal where they could have been of no beneficial use at all. Their extraction has given the householder a far better fuel than if they were left in, and their marketing in the refined form is a very definite addition to the wealth of the community.

There are two further uses for coal, after treatment by low temperature carbonization, which ought not to be overlooked. It is possible to run any petrol or gas engine on low temperature fuel itself, through the medium of what is called a gas producer,

whether the petrol engine is used to propel a car, a motor-bus or a boat, or to drive a dynamo. Secondly, there are other oil-from-coal processes, notably one called the Fischer-Tropsch, which operate to advantage when run as auxiliaries to low temperature carbonization plants.

Now the first new opportunity mentioned above arises from the development of new and compact forms of gas-producers. These devices can produce from either low temperature carbonization fuel or anthracite a combustible gas capable of replacing petrol as a fuel for internal combustion engines. The producer unit, in the case of, say, a 25 h.p. motor lorry is a cylindrical iron casing, about the size of a 10 gallon oil-drum. Inside this casing the fuel is subjected to a process of gradual combustion, under conditions so designed that a considerable quantity of combustible gas is evolved. This gas is drawn, by the natural suction of the engine, through a set of cleaners and dust-traps mounted under the vehicle, and finally into the engine itself where it is consumed in the same way as petrol. It is a perfectly practicable and highly economical system and it has the advantage of helping to make our road and river transport independent of imported fuel. Abroad, many thousands of such vehicles are in use; in fact, in France their use is compulsory. If you are the owner of a fleet of lorries in that country, one in ten of your vehicles must be propelled by producer gas. In this country, its commercial application has been hindered by an obsolete statute which fixes arbitrary limits for the unladen weight of a commercial vehicle. Not only is extra taxation involved by increasing the weight of the vehicle by adding a gas producer but this small increase in weight will also often bring it into the 20 m.p.h. speed limit class. Great though its economy is (its fuel costs per mile are 75% less than those of a similar petrol vehicle) the producer gas vehicle is badly hampered by such out-of-date restrictions, and can never make headway until they are removed. For passenger vehicles, where the weight restriction does not apply, the producer gas omnibus has already proved itself. One Scottish transport company has operated such a bus in the Highlands since 1937 and they state that it is the ideal vehicle where operating costs have to be cut to the last farthing. Other such vehicles are in operation by haulage companies and Government departments. All the technical problems are fully understood, and a new industry of paramount importance to the country and the coal trade could come into existence the moment it is given a modicum of encouragement by the relaxation of out-of-date regulations.

The Fischer-Tropsch process is a method by which petrol and lubricating oil can be produced from coke with the aid of a special catalyst. In brief, heated coke is treated with steam, and the gases evolved, consisting of a mixture of hydrogen and carbon monoxide, are converted into liquid hydrocarbons of the petroleum

series by the agency of catalysts. The Fischer-Tropsch process originated in Germany, and it has been found there that the most suitable kind of coke for treatment is the highly reactive form obtained by low temperature carbonization. In fact, I understand that the standard practice in Germany is now to erect both low temperature and Fischer plants as adjoining complementary units.

It is certainly the logical way of attacking both the coal-oil problem and the coal-industry problem. If a Fischer plant were started in South Wales, in connection with a low temperature carbonization plant as in Germany, it would certainly be a big step forward. Not only would it absorb a considerable amount of coal, but the whole of that coal would be utilized in competition with foreign oil; it would not return to the market in any form in which it could be said to compete with coal itself.

That, I am sure, is the best way of tackling one of the coal industry's big problems; by a rational co-ordinated effort, in which full use is made of the latest technical advances, and in which the national economy is strengthened instead of weakened. Such a combination as that I have described offers far more genuine hope of permanent activity for the coal industry than any system of export subsidies or marketing control which it is possible to devise.

I have considered smoke abatement and coal utilization so far only from our national point of view. But it is just as true that many European coal-importing countries are as anxious over smoke pollution as we are. They would welcome supplies of low temperature fuel of the kind and quality being marketed in England to-day. The home market demand, however, is so far from being satisfied that the export trade must take second place for a while. But the foreign demand is there, for all that, and I should very much hesitate to say that it will necessarily be a matter of many years before low temperature fuel as well as the liquid by-products are a regular and important item in South Wales exports.

DISCUSSION.

Mr. G. H. Barnard (Coal Utilisation Council), referring to the paper by Thomas Dixon, said that the author had omitted from his paper, no doubt from a sense of modesty, to describe developments which coal owners had taken in the preparation of coal for the market. A considerable amount of capital had been expended by collieries in the erection of modern cleaning and grading plants. The appliances mentioned in his paper would not work either smokelessly or efficiently, unless supplied with the correct grade and size of fuel.

Referring to the paper by James Smith he said that various delegates had commented upon the cleanliness and pure atmosphere of the streets in Cardiff. The author was asked to indicate the extent to which electricity

could be applied to trolley buses in cities where exhaust fumes from oil and petrol driven passenger transport services were tending to create an atmosphere of fumes.

Electricity, through the medium of trams, had assisted in the past in keeping Cardiff streets pure from such fumes but, owing to an increase in the number of oil driven vehicles, delegates might find in a few years that the atmosphere of Cardiff streets would not be quite so pure as they would be if trolley buses were used.

Mr. Geo. S. Francis (Electrical Development Association) said that in the discussion that followed the presentation of the four papers under the above subject, in addition to the electrical contribution to smoke abatement in South Wales electricity had made important contributions to this end in Great Britain as a whole. Already practically 80% of the factories and workshops were using electricity for some purpose or another and more electric power was actually being used to drive industrial machinery in this third decade of the 20th century than all the steam, gas and oil power used in industry during the first decade of the century added together. Though it was naturally difficult to give any numerical value to the diminution in atmospheric pollution effected by this development it must certainly be considerable. But while the atmospheric pollution produced by industrial smoke could be controlled to some extent by legislation and municipal action, no such powers existed, nor were likely to be sought, in dealing with domestic smoke, which everyone admitted was the graver evil of the two. Therefore any steps that might be taken to diminish the socially disastrous effects of domestic smoke must of necessity entail a steady and persistent diminution of the use of soft coal as a crude fuel and the encouragement of smokeless methods of producing the heat required for room warming, water heating and the cooking of food, and among the smokeless methods available to-day electrical methods were taking an ever-increasing place. It was, however, unfortunate that progress in this direction was being hampered by public misunderstanding. Many people seem still unaware of the fact that electricity for heating purposes could be obtained in most places at a price well within the reach of all classes of the community. Statements had been made earlier in this Conference in which basic figures for electricity supply were quoted which were only applicable to its use for lighting, whereas by the use of the now familiar domestic tariffs, electricity for heating was available to 70% of the houses connected to public mains at a halfpenny per unit, 85% at three farthings or less per unit or 97% at a penny or less per unit, while only 2.9% was charged over one penny per unit. These differences were largely due to differences in the cost of distribution in the various areas, a factor that was determined by density of population. Mr. Francis concluded by asking that in conferences such as this, to which considerable publicity was given, accurate figures should be given where these were known and that care be taken to avoid making statements that might convey a misleading impression.

Mr. E. B. Johnson (Amalgamated Anthracite Collieries Limited) said

that the delegates would doubtless be able to judge for themselves the veracity of the statements made by each author. It seemed to him, however, that Messrs. Jackson and Smith gave a fair and reasonable review of the position, Col. Bristow dealt with the future while Mr. Clark Jackson reiterated the Gas Industry's plea that they alone were the salvation of the country as regards smoke abatement. At one point he suggested the abolition of the domestic chimney while at another he spoke in glowing terms of the benefits derived from an open domestic fire using coke on specially designed grates. The South Wales coals, including Anthracite, as described by Mr. Jackson, could be used on any type of bar or stool grates, while Dr. Fishenden's investigations had shown that these fuels give better results on coke grates than the fuel for which they were designed.

The idea that domestic chimneys in South Wales caused excessive atmospheric pollution, was definitely disproved by the last report of the D.S.I.R. on Atmospheric Pollution, which showed that the sooty deposit in Cardiff and Edinburgh was higher during the summer than winter and that Cardiff was the only observation station having no hazy or foggy days while Stoke-on-Trent and Victoria Street had 66% and 55% respectively.

Mr. John Roberts said that Mr. Dixon was to be congratulated on his clear, concise and straightforward statement of what the South Wales Coal Owners could do and were doing to help the cause of smoke abatement.

He would like to supplement his remarks by dealing with one aspect of the matter, namely, that the desired object of smoke abatement had not been gained at the expense of satisfactory heating. It was well worth emphasizing that the adoption of methods of reducing smoke need not be attended by increased cost, or the substitution of one hardship to replace another. The Smoke Abatement Society would not be justified in demanding that the public should suffer hardships or inconvenience in any way, merely to overcome the objectionable effects of the smoke nuisance.

Dealing with the solid smokeless fuel side of the question, it was very satisfactory to find that the smokeless fuels, whether natural or manufactured, had higher radiant efficiencies than raw bituminous, smoky coals. Dr. Margaret Fishenden, several years ago, showed that coke, semi-coke and anthracite had appreciably higher radiant efficiencies than typical smoky coals. Dr. Fishenden, at that time, did not test the semi-bituminous smokeless coals. A good deal of work in this direction was still being done, and without drawing any invidious distinctions between the various types of solid smokeless fuels, it would be sufficient to say that there was no manufactured smokeless fuel which gave a higher radiant efficiency than Welsh smokeless coals, similar in type to the first smokeless coal introduced to London 138 years ago by Mr. Lockett, Sir James Duke and Mr. Marychurch, that was, coals of 13 to 14 per cent. volatile content. Coals of that type had recently been tested in an ordinary semi-well, or stool, type of grate, typical of some millions in common use in this country. Low-temperature fuels, free-burning cokes and ordinary gas cokes had been tested in the same grate under similar conditions, and the radiant efficiencies determined by means of his new Thermostat Radiometer, and in every case

the efficiencies obtained with the smokeless fuels were higher than those obtained with very good smoky bituminous coals. For example, a manufactured semi-coke was tested against coal of the same type as that from which the fuel was manufactured, and although 28 per cent of volatile matter had been driven off from the coal in the process, the resulting semi-coke gave a radiant efficiency 29 per cent. greater than that of the raw coal. It was clear, therefore, that the excess volatile matter in typical domestic coals served very little useful purpose from the point of view of radiating heat into the room.

In the case of South Wales' coals, it so happened that what the carboniser did with the smoky coal had already been done by Nature in South Wales. These smokeless coals had already received the necessary heat treatment to eliminate the excess volatile matter, and that is why it was still safe to say that it had not yet been proved possible to improve on Nature's process of making smokeless fuel.

It was recently pointed out by Dr. Marie Stopes that although there lies "in the glowing fire, a magic of some subtle, mysterious, vitally important and health-giving radiance," those rays were not present in the earlier flickering bright flames over black lumps of coal, but they emanated "only when the coals were in a state of ruddy incandescence." It was those rays which she regarded as giving the distinctive biological value to the coal fire. If they accepted that view, then they found that the excess volatile matter was not the agent which threw out what Dr. Stopes had termed "bio-vitric," rays. Therefore, whether they regarded coal from the point of view of radiant efficiency or from the biological standpoint, the presence of excessive amounts of volatile, or smoke-producing ingredients, it appeared to be of no value. There might be, as Dr. Stopes suggested, bottled ultra-violet rays in coal, and if they were to take advantage of these rays, they must ensure that that was not done at the expense of the ultra-violet rays which were continually being emitted from the source of all energy, namely, the sun.

Mr. Turner (Sanitary Inspector, Fulham) took part in the general discussion and said he thought it would be of interest to the meeting to know that, a well-known smokeless fuel was very much used among the poorer classes in his district of London. He did not know whether its cleanliness, convenience of package, or value for money was the deciding factor, but he thought it must be the latter quality as the small quantities in which the fuel was bought rendered it very expensive in comparison with raw coal.

Mr. James Law (Sheffield) said he had listened with interest to Mr. Dixon's paper eulogising the properties of Welsh smokeless coals, and though he agreed with him that those fuels, having a low volatile content, did help in the reduction of pollution where controlled fireplaces and furnaces were being used, there were limits even to the more extended use of that fuel.

He worked in the Yorkshire coalfields where high volatile fuels were prevalent and had to be used. The *wonderful system* of coal control and

quotas at present in operation did not allow the easy importation of South Wales coal into the area, even when manufacturers were prepared to pay the increased price for it.

When he was a marine engineer they were always happy when using Welsh fuel with one exception, and that was the difficulty in starting up furnaces after cleaning. Time was an essential factor in all industry, and engineers and furnacemen could not afford to wait half an hour after cleaning before a furnace has reached a temperature sufficiently high to give complete combustion. The same difficulty arose in the heat treatment of steels. High volatile fuels had an ignition temperature of 700°F. whilst Welsh coals did not ignite until 825°F. The critical temperature for the heat treatment of certain steels was only about 800°F., and perhaps Mr. Dixon would tell him how this difficulty could be overcome with low volatile fuels of the kind he recommended. They found it difficult with Yorkshire coal, but with Welsh fuel it would be almost impossible. An example of that was given in Mr. Clark Jackson's paper where he stated :

"A number of those present will, like myself, be acquainted with towns where the tinplate trade constitutes the staple industry and where the amount of smoke at times from the coal-fired tinpots and more particularly from the coal-fired mill furnaces and annealing furnaces is simply appalling."

Dealing with Industrial Plants, Mr. Dixon spoke of the Combustion Engineers employed by the Coal Utilisation Council who worked in the various areas throughout the country. These men were doing very useful work for smoke abatement and fuel efficiency, but there was work of paramount importance that those men should undertake first, in his opinion.

The Coal Utilisation Council was a subsidiary section of the Mine Owners' Association and their duties were to advocate the more general use of coal. In his area there were twenty-four collieries, eleven coke oven plants, and about thirty spoil-banks. Colliery boiler houses burn low-grade unmarketable fuel under very poor conditions and cause considerable pollution. Coke ovens emitted smoke in dense volumes during charging periods and, in addition, caused pollution from coke quenching. Spoil-banks were an abomination, particularly when they were over-heated. He knew of no industry in Great Britain that carried out its work with such a disregard for surroundings, amenities or adjacent inhabitants.

They had heard a great amount of talk recently from the Coal Utilisation Council about smoke abatement. If those people were sincere with regard to that, he would say in all earnestness: first put your own places in order—boiler houses, coke ovens and spoil-banks; then when you have made these comparable to other industries, you can come along and show other people how to prevent pollution and put their places right, but at the moment it was a matter of "Physician, Heal Thyself."

Councillor Mrs. Alderson Horne (Westminster) remarked that they had heard a good many words on the subject of *stoking*, to the effect that when this was done efficiently less trouble ensued, and she asked why women of the domestic fires were not taught how to stoke, adding that if everyone

present (even) saw to this question in their own homes it would be propaganda which might grow in size and influence.

Mr. C. H. Manley (City Analyst, Leeds, West Riding of Yorkshire Regional Smoke Abatement Committee), stated that although no soot was formed when coke was burnt in a grate, a certain amount of sulphur dioxide nevertheless resulted from the combustion of the sulphur retained by the coke, and this would be converted in the atmosphere into sulphuric acid, with its consequent ill effects upon masonry. The same was probably true also of low temperature carbonisation fuels. (That sulphur dioxide was given off during the burning of coke was evident to anyone familiar with the gas who stood over a watchman's coke brazier.)

The solid smokeless fuels, whilst representing a marked advance towards the solution of the atmospheric pollution problem, must therefore in this particular respect take second place to coal gas, so far as the domestic chimney was concerned, for there no installation of scrubbing plant was possible.

Mr. Thomas Dixon, replying, thanked Mr. Barnard for his valued observations on the importance of correct sizing and grading of fuels for the appliances referred to in his paper with which he, the speaker, agreed. The number of different sizes of coal made was very great and the nomenclature in use in different coal-producing districts, and even in different parts of the same district, for certain sizes was very confusing. A good deal of work had been done by the industry with a view to reducing sizing and nomenclature to an orderly basis and he thought it likely sizes would eventually be signified by numerals.

He was much obliged to Mr. John Roberts for his remarks supplementing the arguments in the paper and particularly for his most interesting remarks on the relative radiant efficiencies of the various types of fuel he had mentioned.

In reply to Mr. Turner he said he regarded the prices of Welsh smokeless coal in London as being reasonable and thoroughly competitive having regard to their intrinsic properties.

He thought the heat treatment difficulties to which Mr. Law referred might be satisfactorily dealt with by the application of producer gas and, as regards the difference in ignition temperatures of high and low volatile coals, this had to be accepted as a fact and of course combustion practice required to be adjusted appropriately.

He did not quite get the bearing of Mr. Law's remarks regarding the Coal Utilisation Council but it seemed to him the main purpose of this Council was clearly indicated in its title.

He was glad to hear from Mrs. Horne of the preference of poorer people with whom she came in contact for smokeless fuel—in this he considered they showed commendable judgment.

Referring to the complaints of Mr. Law and of an unnamed speaker that coal control was preventing consumers having the coal they desired; he doubted if this were really so and drew attention to the assurances given

by the Coal Industry in connection with the schemes for organised selling to safeguard consumers in this respect.

Replying to Mr. Manley he thought a remedy might be the use of the smokeless coals of very low sulphur content referred to in his paper.

Mr. Clark Jackson, in reply to Mr. Francis, said that apparently it served the purpose of Mr. Francis in his remarks to entirely disregard the work done by the Gas Industry towards smoke abatement, and the fact that this industry which Mr. Francis overlooked was an industry which only carbonised the negligible quantity of approximately 18 million tons of coal per annum.

It could also be inferred from the remarks of Mr. Francis that the housing estates recently erected and now being erected in and round about London were all electric, but this was not correct as there were very many of these housing sites actually being fitted out as all gas houses.

He had in his possession a copy of the paper given by the late Sir Philip Dawson, M.A., M.P., before the British Gas Federation Joint Gas Conference at the British Industries Fair, Birmingham, 1938, in which he made mention of several housing sites in London where gas and coke were the fuels used and as a result of which there is an entire absence of smoke and where in addition the cost to the tenant of these two fuels worked out cheaper than the average cost of houses fitted out with any other type of fuel.

Furthermore Mr. Francis had to admit that in his all electric house one coal fire was provided for winter use—where did smoke abatement come in?

Mr. Johnson was certainly not correct when he stated that he had set out to give the impression that gas was the only fuel capable of promoting smoke abatement.

If Mr. Johnson would look at the final remarks of his paper he would see that he definitely stated that there were other industries and many other agencies whose work during these past few years had also resulted in the reduction of smoke emission, and that papers dealing with their efforts were being read before the Conference, also that he would regret if the contents of his paper were misconstrued as even with the concerted efforts of the whole lot of them they were still a very great way off from the goal which the National Smoke Abatement Society stood for, namely, a smokeless, and therefore a healthier, Britain.

He would be very foolish to say that gas was the “alpha and omega” so far as smoke abatement fuel was concerned.

He appreciated the work capable of being done by anthracite, low volatile Welsh coals, Coalite, and such like fuels, and there was definitely plenty of room for everyone of these to co-operate in the great work.

Mr. Johnson had also mentioned that gasworks themselves were smoke producers, but with modern gasworks plant cases of that type were very few and far between, and even with anthracite, had Mr. Johnson been present at the morning session and heard the complaint of a councillor living in an anthracite district as to the clouds of anthracite dust which was given off by the screening plant and which was literally making life

almost unbearable for those compelled to live within the neighbourhood of the colliery, he might have refrained from mentioning the name of gasworks in that category.

In reply to Mr. Roberts, he agreed that coke grates were quite capable of burning low volatile Welsh steam coals, and that there was quite a wide field for the use of low volatile Welsh steam coals as a smokeless fuel.

Mr. Manley had spoken as to the amount of sulphur in coke, but surely he was bound to admit that as coke only represented a part of the original coal, and as a considerable amount of sulphur was given off in the crude gas, and which had to be removed from gas under penalty by gas undertakings, the amount of sulphur left in the coke could only be a portion of the total amount of sulphur in the original coal, and that therefore coke as a fuel could not possibly contaminate the atmosphere with sulphur fumes to the same degree as coal, where practically the whole of the sulphur was given off and carried away in the smoke.

Mr. J. F. Smith, replying to the question raised by Mr. Barnard, stated that the controversy of trolley buses versus oil driven vehicles was one very pertinent at the present time in the City of Cardiff. His personal opinion was that the objects of public transport should be kept well in mind, which objects obviously were to transport large numbers of persons cheaply, rapidly and safely.

For the permanent routes used by the majority of the population trolley buses appeared to meet those requirements, while for long and relatively sparsely populated suburban routes and special traffic petrol or oil driven buses were obviously the more flexible and probably the cheaper.

It would be desirable if such vehicles used home-produced petrol or oil.

Since the configuration and distribution of population of each town presented its own special features, no hard and fast rule could be laid down as to the relative merits of trolley buses and oil driven vehicles, and in Mr. Smith's opinion in many cases it would be found that a combination of both modes of transport would prove the best solution.

Colonel Bristow, replying, said there was less sulphur in prepared fuel than in raw coal, and that a chimney had no downdraught if properly designed, constructed, and kept. His company supplied "Coalite" for the "quads" at St. Neots, and the doctor took samples of the air in the room every two hours until everyone was satisfied there were no fumes.

The fuel was good and only superficially expensive—and there was a terrific margin between the price at the works and the price to the consumer. The reason that so many poor people used it was that in the main they were the only class who knew really how much their fuel did cost.

Colonel Bristow concluded by saying that the new enterprise in South Wales would not compete with Welsh coals, but was an additional method of putting South Wales coal on the map, supporting the efforts of the Society to make a smokeless country, and providing fuel, petrol, and oil.

Saturday Morning, 3rd December: Annual General Meeting.

DISCUSSION ON BURNING SPOILBANKS.

Councillor T. M. Rowe (Northumberland and Durham Advisory Regional Smoke Abatement Committee) read a Memorandum by Alderman David Adams, M.P., who was unable to be present.

The question of colliery spoilheap fires in Northumberland and Durham has received the serious and repeated consideration of the Northumberland and Durham Advisory Regional Smoke Abatement Committee. Deep resentment has been expressed by municipal representatives of mining areas on behalf of their constituents, many of whom have suffered for years ill-health, discomfort and damage to household furniture and gardens, etc., from emissions from such fires. The local authorities have not the requisite statutory powers to act, and the local colliery owners, whose obligation this is, have in the main avoided their responsibilities. For these reasons, the above committee on June 17th, 1938, unanimously passed the following resolution :—

“That this Council desire to place before the Conference of the National Smoke Abatement Society the suggestion that Authorities affected should unite to provide the cost of a test case in order that a more satisfactory state of affairs may be arrived at in this much-complained-of nuisance which affects so seriously the health of the inhabitants of many localities in the Country.”

They authorized me if I thought it advisable to press this resolution before your Conference.

It is now found that the existence of this nuisance brings it within the ambit of National Defence in the matter of providing beacons for enemy aircraft. As serious action is at last being taken by the Government, I have decided not to press the resolution. The Ministry of Health report that they have scheduled the 214 collieries where burning pit heaps exist; that five additional inspectors have been appointed for this duty, and that inspections in the first instance are being made from the air, and that remedial measures under expert guidance from the Ministry are being instituted. The work is carried out by the colliery companies concerned and in some cases in co-operation with the local authorities of the area. It is interesting to note that the Parliamentary Secretary to the Home Department, Mr. Geoffrey Lloyd, M.P., stated in the House on June 16th last that expenditure by a local authority under this head may rank for grant under Air Raid Precautions expenditure,

It may be further added that the Ministry of Health in response to questions in the Commons was vague as to the important reform of the prevention of further dumping of pit waste likely to become inflammable—particularly near housing areas. This question should receive the close consideration of this Conference. Should Mr. W. A. Damon, Chief Inspector of Alkali Works, etc., be present, it will be of great advantage if he will inform this Conference, and the country generally, what the Ministry are doing and intend towards the complete solution of this problem.

I attach herewith the question and reply upon this subject, addressed to the Minister of Health in the House on November 3rd.

Mr. David Adams (Lab. Consett):

To ask the Minister of Health, if he will state the steps taken by his department to deal with the public nuisance and danger arising from burning spoilbanks, the numbers in which remedial measures are in operation, and when it is anticipated that the whole of these will have been finally dealt with.

Mr. Elliot:

The systematic investigation of burning spoilbanks by my Alkali Inspectors is proceeding. 151 out of a total of 266 reported to me have been visited. Further visits will be necessary in some cases to ascertain the practicability of remedial measures. Wherever remedial measures have been recommended by the Inspectors further visits are being undertaken to determine the efficacy of the measures. I estimate that the completion of the survey will take approximately another eighteen months.

DISCUSSION.

Councillor J. W. Davenport (Manchester & District Regional Smoke Abatement Committee) said that coming from a colliery district which had suffered greatly as a result of burning pit heaps he welcomed any effort made to impress the Government that legislation on this subject was urgently required.

During the 1926 coal stoppage a colliery heap got on fire. After finally being extinguished it was found that the fire had converted the tip into a saleable product "red shale." Since that time they had had trouble from first one and then another tip.

Mr. J. Tinker, M.P. for his division (Leigh) had very persistently protested against the nuisance for a number of years. Teachers and scholars in day elementary school had great difficulty in carrying on owing to the irritation to throat and nose. Householders on every hand were complaining of the effect of the fumes upon health and furnishings.

Efforts were made to get powers to regulate the putting down of these tips, during the formation of their Town Planning scheme, but so strong was the opposition they were compelled to withdraw their proposals.

Efforts to put out the fires by the use of water often only aggravated the nuisance.

Legislation should aim at abatement of the present nuisance, and to so control the laying down of future tips that no nuisance would be likely to arise from them.

Councillor J. Forster (Whiston R.D.C.) said that there had been considerable discussion on the treatment of burning spoilheaps or colliery refuse tips. It was a mistake to say that little or nothing had been done by colliery companies or other works to remedy those burning tips.

In the district of Bold, a part of the area covered by the Whiston Rural District Council, Lancashire, which he had the honour to represent, there were four collieries, and three had burning tips.

One colliery had spent more than £3,000 in trying to put out the fire, and to prevent its recurrence. The fire in that case had got a good hold right in the centre of the heap, which was approximately 50 feet high, flat at the top, with a base of about 470 yards by 130 yards.

A thick coating of slag dust from an iron works was placed over a part of the burning heap about 9in. to 12in. thick. This smothered the fumes, and prevented the outbreak of open flame for a time, but was not completely successful as the covering cracked, allowing the ingress of air to feed the fire which still burned underneath.

Later the fire started in a section of the heap which had been arranged to form a gradient above the pits to gravitate empty wagons to be loaded at the screens. On this heap stood an electrically driven saw mill, washer, and stacks of thousands of props and bars ready for use down the mine when required. The fire broke out in the first place under the circular saw bench, next under eleven railway points and crossings, and again under the timber yard, and the washer.

Mr. H. Price, B.Sc., Agent and Manager, used the following treatment :

Limestone dust and water was fed through perforated iron tubes about 3 inches diameter, into the seat of the fire. This method proved so highly successful that at no time was it necessary to stop work in the above mentioned parts of the works, and the parts treated had since remained dead, there being no further outbreaks of fumes or fire.

When the larger heap was on fire a local farmer attributed a successful year for his cauliflower plants to the fact that the hot sulphur kept the frost from attacking them in the winter. These plants were in demand as far afield as Wales and Glasgow.

Round the tip a huge drain had to be cut to enable the water to be treated. Water pits and ditches had to be fenced and cleaned out, and for a time Town's water had to be provided for the cattle until the ditches were cleaned by storms.

On one occasion his Council threatened to force one colliery to try some remedy to abate the nuisance of the burning tip. The company could not afford to spend money, and if forced to do so, would have had to close down,

This would re-act on the Council because few, if any rates would be paid if the Company closed down and the people were unemployed.

The speaker from Glasgow had mentioned the method used in his district. That idea was to pour water on a cone shaped burning heap. He maintained from experience that this method tended to aggravate rather than remedy the trouble.

From personal knowledge he knew that the method applied by Mr. Price was a very sure remedy.

He had written a paper dealing with the subject which has been read in Manchester, a copy of which he had handed to the Chairman of the Conference.

Dr. A. S. Hebblethwaite (Sunderland) described the measures which had been taken by the colliery companies in the area immediately surrounding that Borough.

The nuisance from burning pit heaps showed itself in the householders being unable to open windows within half a mile of the spoilbank in certain directions of the wind. Baths were discoloured brown, paint was turned black, silver was tarnished and ladies had complained of metallic dresses also being turned different colours. Dr. Hebblethwaite explained in detail the fact that the discoloration of the baths was due to the action of sulphur in the fumes on the lead glaze of the baths, whereas lavatory basins, and W.C. pedestals being of a salt glaze, they were unaffected.

Various tests were carried out by the exposure of plates coated with lead oxide, which were discoloured by the formation of lead sulphide. Various indications were also given as to the effect upon health of these fumes.

Aggravation of the existing nuisance due to such fumes had been caused lately by the setting up of a coal washing plant to provide cleaner coal, on the demands of the public. As a result of that, sulphur in the form of pyrites was washed off the coal and heaped on pit heaps, and the combustion of this debris gave rise to the nuisance. Previously the sulphur had been consumed by the public as part of the coal.

Dr. Hebblethwaite further discussed the measures which the colliery company had undertaken in order to prevent this nuisance. At first, many thousands of gallons of water had been poured on to the tip, but that aggravated the nuisance by washing away inorganic material and leaving channels and gullies, which caused an ingress of air which supported combustion.

The present method, which had been continued for some months, consisted in an attempt to seal hermetically the top and sides of the heaps. This was carried out by the deposition of thousands of tons of earth, sand, and marl taken from neighbouring housing estates during their course of development.

Rolling flat the tops of the heaps was easy, but it was more difficult to get a hard, smooth impervious surface for the sides. Heat generated in the heap showed itself in cracks on the heap and oil and sulphur was

brought to the surface. These cracks required regular supervision and occlusion in order to keep air away from the centre of the heap.

The only method by which the nuisance, in the future, could be prevented would be, on the North East coast at any rate, to take the spoil away to sea.

Dr. Hebblethwaite finished by paying tribute to the very great pains which the colliery companies had taken in helping local authorities in the abatement of this admitted nuisance.

Alderman J. Lynch (Burnley) said he wanted to support any action the Smoke Abatement Society might take in that matter because at Burnley some three or four years ago they had an experience with a spoilbank that would live in their minds all their lives. The spoilbank was situate in a densely-populated part of the town and the first intimation of a nuisance was a foul smell in the air which increased as time went on and eventually the whole area was enveloped by smoke and fumes that were unbearable for any length of time. The user of the spoilbank introduced intensive flooding operations and for a short period some improvement was noticeable but later the district was subject to further occurrences of the nuisance and a plague of bats and beetles. The land was owned by the Corporation which subsequently served notice to terminate tenancy to the user, who took some other land not very far away. The Corporation took over the spoilbank and after a time began to use it for tipping their own refuse by the "controlled method" and it was suggested to the previous user that this method should be adopted on their new site. This suggestion was acted upon and they had had no nuisance for about eighteen months. As a consequence of what the people in their town suffered while the nuisance he had referred to was in being he was sure Burnley Council would unanimously support any action the society might take in order to rid the country from the menace of burning spoilbanks.

Mr. E. Robinson (Houghton-le-Spring U.D.C.) said he wished to support the Society in any measure that they might adopt for supporting the present Bill in the House of Commons for dealing with the burning spoilbank nuisance, and also endorsed the remarks made by Dr. Hebblethwaite regarding those heaps in the County of Durham.

In his own particular district the colliery company had made an effort to deal with the burning and had successfully dealt with one heap by "blinding" or "blanketing" it with sand, after cutting a separating division around the burning portion.

Councillor Mrs. Alice Bunn (Stepney) said she was not concerned with the financial side, as seemed the case with so many of the previous speakers. They were members of the National Smoke Abatement Society and as such the financial side was no concern of theirs. The illnesses which were caused by the pollution of the air and the money that was spent by the Ministry of Health in trying to keep people well would more than pay for the abolition of unsightly spoilbanks. It was the duty of the Ministry to find a way out and if they had not the experts they had the ways and means of getting them.

Mr. James Law (Sheffield) said he would like to clarify the position with regard to this matter. They had heard an amount of discussion with regard to the various methods of dealing with this form of nuisance, but he suggested that remedial measures were not the concern of the Society and had no bearing on the resolution being put to the meeting.

Dr. Hebblethwaite, of Sunderland, and other speakers had mentioned "test-cases" to be taken at some future date, but there are legal records already dealing with this form of nuisance. As far back as 1883 it was decided that a "burning refuse heap" was a nuisance that could be dealt with under the nuisance section of the Public Health Act—Section 92, sub-section 1, clause (c)—"Any accumulation or deposit which is prejudicial to health or a nuisance." Though the plea of being prejudicial to health was not pressed, it was decided that a nuisance existed which should be dealt with under the provisions of the Act. He referred to the case of the *Bishop Auckland Local Board v. The Bishop Auckland Iron Company*—Justice of the Peace Manual, 1883, Volume 47, page 389.)

Nuisance of that kind should be dealt with by local authorities and if no action was taken in the matter, local authorities were not carrying out their duties. Though Mr. Lawson's Bill now before Parliament had been read for a second time and reached the Committee Stage, they had no guarantee that it would proceed much further and even if it did the obligation to take action would still remain with local authorities. Possibly many representatives of local authorities were not aware of that and it was for the purpose of drawing their attention to it that he had quoted the case previously stated.

Mr. John Roberts said that although this matter was of vital interest to colliery owners, no invitation appeared to have been given to colliery owners to express their views. He suggested that the resolution should be carefully worded so as to avoid antagonising the colliery owners. It was obvious too, from the remarks of previous speakers, that the colliery managements in many districts were in full sympathy with the objects of the Society, and they had expended large sums of money in their attempts to meet the nuisance. In his view, the Society would make greater progress by seeking the co-operation of the mine owners, rather than by antagonising them.

Dr. Millar (Medical Officer of the Chester-le-Street Rural District) said that he came from a district where the question of burning spoilbanks was giving a good deal of concern. He agreed that a local authority had power under the Public Health Act to deal with a burning spoilbank as a nuisance, but it was sometimes difficult to put this nuisance clause into operation because (1) of the difficulty of proving that the best practical means of abating the nuisance were not being put into operation by the colliery company and (2) the threat by the colliery company to close the pit if proceedings were instituted.

Several of the pit heaps in the Rural District of Chester-le-Street had been dealt with successfully by continuously pumping water into the heap or pumping a clay grout into the heap.

The difficulty as Dr. Millar saw it, was not dealing with a burning spoilbank but of dealing with refuse heaps before they fire and he suggested that this was a matter more for the Ministry of Mines than for the Ministry of Health. Local authorities required legislation to deal with the deposit of refuse from collieries before they took fire.

Mr. Damon (Ministry of Health) said that as the administration of the Public Health Act was in the hands of the local authorities, it was for them and not for the Ministry of Health to take action. The Ministry were, however, sympathetic and appreciating the difficulty of meeting a b.p.m. defence, were anxious to help. With a view to ascertaining the best preventive measure, the Alkali Staff were engaged in making a survey of some 270 spoilbanks. Progress was being made and over half of them had now been inspected. Some were burned out, others showed no tendency to fire, the remainder being either in a smouldering condition or burning freely. He welcomed Mr. Robert's reasoned and constructive remarks. These fires were not, for the most part, deliberate. The problem had come along gradually for reasons set forth by Mr. Roberts and in the great majority of cases, the colliery owners were anxious to co-operate and give any help possible. In those few cases where no interest was displayed and no remedial steps attempted it would seem clear that a b.p.m. defence must fail.

The spontaneous combustion of spoilbanks was due to an accumulation of heat generated by the slow oxidation of carbonaceous matter and possibly pyrites. In general, it might be said that spoilbanks into which air could not enter would not fire, and it was therefore desirable to (1) reduce carbonaceous matter in the waste to a minimum and (2) pack the refuse in a dense mass or otherwise make it impervious to air.

Blanketing had proved successful in some cases and unsuccessful in others. The same might be said of attempts to flood or grout with clay or stone dust. There was no universal cure and no prospect of an immediate one for this very difficult problem. The matter was one for patient investigation and experiment which must inevitably take a long time. Investigations were now being pursued along two lines (1) the extinction of existing burning spoil heaps and (2) the establishment of methods whereby spoil could be stacked without risk of firing in the future. Of the two branches the second was probably of greater importance.

Those interested would find some information on the subject in the 74th Alkali Report in which certain broad conclusions, arrived at as a result of the examination of a number of spoilbanks, were quoted.

Finally there was the difficulty that even unfired spoilbanks were extremely unsightly. In this connection it was interesting to know that in Somerset, certain old spoilbanks had been planted with Scotch Firs. These appeared to thrive very well and the resultant effect was very pleasing.

Resolution.

The following resolution was proposed by Councillor W. Asbury (Sheffield), was seconded by Councillor Didden (Hove), and carried unanimously:

THAT this Conference welcomes the Bill introduced into the House of Commons by Mr. J. J. Lawson, M.P., with the object of dealing with burning spoil banks, and urges the Government to give full and immediate support in making legislation effective.

THAT copies of this resolution be forwarded to the Prime Minister and appropriate Government Departments, and also to all Local Authorities affiliated to the Society requesting them to endorse the resolution and to forward copies to the above and to their local Members of Parliament.

OTHER RESOLUTIONS PASSED AT THE CONFERENCE.**Public Utility Undertakers.**

(Proposed on behalf of the Borough of Hove).

Resolved:

That this Conference urges upon H.M. Government, as a condition precedent to their assent to any extension of the Works of Public Utility Undertakers, to insist upon the installation, so far as is practicable, of plant designed to prevent the emission of smoke, soot, ash, grit and gritty particles from the chimney shafts or from any other portions of their Undertakings.

Local Authorities: Smokeless Premises.

(Proposed on behalf of the Executive Committee).

Resolved:

THAT this Conference of the National Smoke Abatement Society is of the opinion that in addition to all other action to promote smoke abatement, Local Authorities should ensure completely smokeless conditions in all premises under their control, thus setting a valuable example to the rest of the community and giving added force to their other smoke abatement work. The Conference is also of the opinion that it would be of value to ascertain the progress already made in securing smokeless conditions in buildings under public control and requests the Executive Committee to make the necessary enquiries for that purpose and report thereon,

PUBLICATIONS of the NATIONAL SMOKE ABATEMENT SOCIETY

(All prices include postage. Reduced prices for quantities).

RECENT PUBLICATIONS.

The Law of Smoke Nuisances. By W. R. Hornby Steer, M.A., LL.B., Recorder of South Molton, Standing Counsel to the Society. This book, based on an earlier work by Randolph A. Glen and revised and extended in accordance with the Public Health Acts of 1936, is likely to be accepted as a standard work on the subject. In addition to the explanatory chapters, it contains tables of statutes and cases and the relevant sections from the two Acts and the Local Government Act, 1933. 8vo. 65 pages. 1/- paper-backed ; 2/6 cloth-bound.

Britain's Burning Shame. This pamphlet has been described, in a review, as "a masterpiece of modern popular propaganda." It puts the smoke problem in its simplest terms, especially as it affects the home, and is profusely illustrated. Invaluable for meetings, exhibitions, and in any campaign based on smoke abatement. Single copies 2d. 12/6 per 100. £5 per 1,000.

The Case Against Smoke. A booklet which is intended to give the reader a clear understanding of the nature and extent of the smoke nuisance by means of passages from a number of writers and speakers, each of whom may be regarded as an authority in his own sphere. There are also figures and extracts from official reports and tables. Invaluable for those who write and speak on the subject. 24 pages. 4to. Price 3d.

Proceedings of the Science Museum Conference (1936). The most complete review of the problem to be published for many years. Twelve papers and discussions in full.

Technical: Methods for the Prevention of Grit and Dust mission by A. T. Barber and T. F. Hurley (Fuel Research Station); Smoke Prevention in the Iron and Steel Industry, by H. C. Armstrong; Smoke Emission in the Clay Industries, by E. Rowden and A. T. Green; (British Refractories Research Association).

General: Solution of the Domestic Problem, by Dr. M. Fishenden; Through a Glass Darkly, by Noel Carrington; Effect of Pollution on Vegetation, by Sir Arthur Hill and Dr. C. R. Metcalfe (Kew Gardens); Developments in the Investigation of Pollution, by Dr. J. S. Owens. Health: Pollution in Relation to Tuberculosis, by Sir Pendrill Varrier-Jones; Light and Clean Air in Relation to Surgical Tuber-

culosis, by Sir Henry Gauvain; Obstruction of Light by Smoke and its Effect on Health, by Sir Leonard Hill.

Administration: Public Health Administration and Smoke Abatement, by Dr. A. S. M. Macgregor (M.O.H., Glasgow); Smoke and the Sanitary Inspector, by H. G. Clinch (C.S.I., West Ham).

112 pages, 4to. Price 2/-. Limited quantity only available.

Handbook and Guide to the Science Museum Exhibition. The Handbook is not only a detailed guide to the Exhibition, but containing a series of twelve authoritative articles on the main aspects of the problem, is a permanent and useful reference book. There is a foreword by the Minister of Health, and in addition there is a series of communications from correspondents abroad on progress being made in other countries. 80 pages. Medium 8vo. Price 6d.

Smokeless Airs. The Society's quarterly Journal is a magazine—the only one in the world—devoted to the problems of atmospheric pollution. Contains authoritative articles, notes on technical subjects, news of activities of every kind, and in general keeps the reader up-to-date in every aspect of the subject. Per annum, 2/6. Gratis to members.

Fumifugium: or the Smoake of London Dissipated, by John Evelyn. This rare and fascinating book, first published in 1661 by command of Charles II., has been republished by the Society with an introduction by Miss Rose Macaulay. In spite of its age this indictment of the smoke evil by the author of the famous Diaries remains true, witty, and penetrating. Illustrated with original wood engravings and a portrait of Evelyn. Paper covers 6d. Cloth-bound, 1/6.

Smoke and Fumes Nuisances from Road Vehicles. The technical and scientific aspects by Dr. J. S. Owens, A.M.Inst.C.E., M.I.Mech.E., and the legal position by R. P. Mahaffy, M.A. 8vo. pp. 16. 3d.

Smoke and Aviation. Full Report of the 1935 Conference on this subject. Four papers in full and discussions. "Smoke and Visibility," by C. S. Durst, B.A., Assistant Superintendent, Meteorological Office, the Air Ministry. "The Effects of Smoke upon Flying Conditions," by William Courtenay. "The Effects of Smoke upon Flying in the North," by Alan Goodfellow, "Visibility and Smoke in Relation to Aerial Photography," by Captain Alfred G. Buckham, F.R.P.S. With photographic illustrations. 8vo. pp 40. 1/-.

Smokeless Open-Grate Fuels. Report of the Symposium held in 1934. Papers and discussions on all types of solid fuels, their uses and requirements, by E. K. Regan, E. W. L. Nicol, Col. W. A. Bristow, H. Cerckel, Mrs. G. H. Miles, Dr. G. E. Foxwell, John Roberts, and Dr. E. W. Smith. 8vo. pp. 60. 1/-.

The State of the Atmosphere.—"An Examination into the Effects of Atmospheric Pollution on Building Stones, etc., with a Preliminary Summary of the Conditions Disclosed by various Enquiries into the State of the Atmospheres of Great Britain," by Sir Frank Baines, K.C.V.O., C.B.E., F.R.I.B.A. An invaluable survey of the subject. Royal 8vo. pp. 36. 6d.

Home Fires Without Smoke. Edited by Cyril Elliott and Marion Fitzgerald. 8vo. pp. 59. Cloth-bound remainders, 6d.

The Smokeless Home. A popular 12-page illustrated pamphlet. with covers in colours, describing the ways and means for making the home smokeless. To be sold in quantities for general distribution. Single copies gratis. £5 per 1,000.

"Smoke Abatement and Fuel Economy in Steam Boiler Practice" (Published by the Manchester and District Regional Smoke Abatement Committee). pp. 11. 1d., post 2d.

N.S.A.S. Annual Reports. Gratis, by Post 1d.

PROCEEDINGS OF THE ANNUAL CONFERENCES.

Each with all papers in full, and discussions. 8vo. Price 1/- each.

Newcastle, 1932. Presidential Address and papers on: "The Domestic Smoke Problem: the Possibilities of Coke-Oven Fuel"; "The Psychological Effects of Smoke"; "The Human Element: A Factor in Smoke Abatement."

Glasgow, 1934. Presidential Address and Resolutions, and papers on: "The Measurement of Atmospheric Pollution"; "The Effects of Smoke upon Visibility and Aviation"; "The Effects of a Smoke-Laden Atmosphere on Horticulture"; "Nature in Beautiful"; "Slum Clearance and the Smoke Problem."

1933 and 1935—out of print.

1936—See page 76.

Leeds, 1937.—Presidential and Chairman's Addresses, Papers on Town Planning and Smoke Abatement, The Regional Smoke Abatement Committees, and Education and Smoke Abatement.

SMOKE ABATEMENT in Greater London



**REPORT OF A CONFERENCE
held on 25th February, 1938**

PRICE : SIXPENCE

**REPORT of a CONFERENCE
of London and Greater London
Local Authorities**

**held at the County Hall, Westminster Bridge
on Friday, 25th February, 1938**

CONTENTS.

Report of the Proceedings of the Conference and Text of
the Resolution approved 3

Papers :

 “The Present Position and Trends of Atmospheric
 Pollution in Greater London,” by Dr. J. S. Owens 5

Address by Mr. E. H. Keeling, M.C., M.P., on Moving
the Resolution 13

Address by Mr. W. A. Damon, Chief Inspector of
Alkali, &c., Works 16

Address by Mr. W. H. Hornby Steer, M.A., LL.B.,
F.R.San.I., on Seconding the Resolution 20

List of Authorities Officially Represented 22

REPORT OF PROCEEDINGS.

The Conference was convened by the National Smoke Abatement Society with a view to promoting a discussion on how smoke abatement could be further advanced in the Greater London area, and with particular reference to the possibilities of the formation of an Advisory Regional Committee.

The Conference opened at 2-30 in the afternoon in the Conference Hall of the County Hall, Westminster Bridge, the Chairman of the London County Council, the Rt. Hon. Lord Snell, being in the Chair. Lord Snell in a short address opening the proceedings welcomed the delegates on behalf of the London County Council and expressed the hope that the results of the Conference would lead to a brighter London and a London freed from smoke.

The papers which are printed in full in this Report were then read, and the following resolution was moved by Mr. E. H. Keeling, M.P., and seconded by Mr. W. R. Hornby Steer, L.C.C. :

“That this meeting is of the opinion that steps should be taken to promote the formation of an Advisory Regional Smoke Abatement Committee for London and Greater London and requests the National Smoke Abatement Society to report to the Authorities concerned, asking them to agree in principle to the proposal, and to be represented at a further meeting to be convened for the purpose of establishing such a Committee.”

After a short discussion, in which Councillor Mrs. Alderson Horne, Sir David Milne-Watson, Alderman C. W. Daines, C.C., Councillor T. Turner, and Councillor the Rev. E. Burgess, took part, the resolution was put to the meeting by Dr. H. A. Des Voeux, President of the National Smoke Abatement Society (who took the Chair upon the retirement of Lord Snell from the meeting) and was unanimously carried.

After an informal vote of thanks to Lord Snell, the speakers, and Dr. Des Voeux, had been carried, the meeting was declared closed.

THE PRESENT POSITION AND TRENDS OF ATMOSPHERIC POLLUTION IN GREATER LONDON.

By J. S. OWENS, M.D., A.M.I.C.E., M.I.Mech.E.,
Superintendent of Observations for the Investigation of
Atmospheric Pollution, Department of Scientific and
Industrial Research.

The subject matter of my remarks, as the title indicates, is the condition of Greater London with regard to atmospheric pollution, dealing particularly with the present degree of pollution and whether it is reducing or not.

I propose, therefore, to indicate briefly the position as found during the last year, that is 1936-37, by the measurements taken in the Investigation carried out under the Department of Scientific and Industrial Research.

To take an intelligent interest in this, it is necessary to describe briefly the nature of the measurements made :—

Deposit.

One method is to estimate the amount of impurities which fall upon a given area, and this is done by means of a standard deposit gauge consisting of a simple open topped glass vessel delivering the rain and deposit into a bottle underneath. The deposit is collected monthly, analysed, weighed and the results converted into tons per square mile.

Suspended Matter.

The very finely divided sooty matter which forms city fogs and which does not deposit rapidly is estimated by a special filter which extracts the black impurity from a fixed volume of air upon a white filter paper, and permits an estimate of the concentration to be made. This is usually expressed in milligrams per hundred cubic metres.

Sulphur Pollution.

Sulphur is measured in two ways : the concentration by a volumetric method which gives the amount in a known volume of air, and the "activity" of the sulphur by exposing cylinders coated with lead peroxide for one month to the air. The concentration is usually expressed in volumes of SO_2 per million and the "activity" of the sulphur in milligrams of SO_2 per hundred square centimetres per day.

It is unavoidable that to give any clear picture of the London conditions, one is driven to the use of tables of results and figures for deposit, concentration and so on. There does not appear to be any other means available, so that however unpleasant they may look, no apology is needed for having to put forward tables of figures.

Present Position in London.

Deposit.

To bring out this Table 1* shows for eight London stations the amount of deposit recorded in 1936-37 under the headings of total solids, sulphates and tar. You will see that these range from a total deposit of 322 tons per square mile at Archbishops Park to 172 tons at Wandsworth Common. The deposit of sulphates lies between 53 tons per square mile at Finsbury Park and 22 tons at Wandsworth Common, while tar ranges from 7 tons per square mile at Golden Lane to 2 tons at Wandsworth Common. The individual stations show some variation as is to be expected since they are affected to some extent by local conditions.

At the bottom of the table, the average for all the eight stations is given, and this amounts to 238 tons of total deposit per square mile, 34 tons of sulphates and 4 of tar, quite a respectable deposit for a city in which people have to live and carry on their activities.

Suspended Impurity.

So much for the present condition as measured by the deposit of impurity. When we look at the suspended impurity, that is the black sooty matter which one breathes in London, and consider the winter of 1936-37 and the concentration in mgms/100m³, we find that at Victoria Street the highest concentration was found, that is 69, the next was at Westminster City Hall with 65, Westminster Bridge County Hall 38 and South Kensington 31. A little further west at Kew it had dropped to 15. The quantity is comparatively small looked at in one way, but when we remember that it is this suspended matter which obscures the light, produces smoke fogs and blackens the lungs of city dwellers, it takes on a different importance and, owing to the excessively small size of the particles, that is an average of about 1/40,000 in., a small quantity distributed through the atmosphere has a great effect, and further, the small size allows the suspended matter to penetrate almost anywhere air can enter.

To give an idea of how this compares with other cities, the average of the five London stations during the winter 1936-37 was 44, the average for five Glasgow stations for the same period was 63 and for one station at Stoke 85.

Sulphur.

During 1936-37 the average concentration of sulphur dioxide in the air of London has taken from three stations was 0.109

* These tables are printed at the end of the paper,

which compares with an average of 0.096 for Glasgow and 0.148 for Sheffield for the same period. The activity of the sulphur is a measure of the rate of attack on building stones and exposed metal work, and this during 1936-37 averaged for seven London stations 3.81 mgms./100 sq. cm. per day compared with 2.65 for Glasgow, 2.07 for Sheffield and 4.65 for Salford. It will be seen from the figures given that there is room for improvement in the condition of the air of London and, when dealing with the trend or the rate of improvement observable in London, it will be evident that some greater effort than we have been making in the past is required to purify the air.

There is no doubt that for some reason London of recent years has suffered from excessive sulphur pollution. If we take, for example, the highest recorded figure in mgms. of SO_2 per 100 sq. cm. per day, we find the following figures :—

	1933-34		1934-35		1935-36		1936-37	
	Ave for yr.	High't Month	Ave for yr.	High't Month	Ave for yr.	High't Month	Ave for yr.	High't Month
London :—								
Government Laboratory...	4.13	7.47	3.57	6.20	—	—	—	—
County Hall	4.69	9.42	4.11	7.97	5.05	8.59	5.60	11.90
Chelsea	3.99	7.32	3.16	6.65	3.72	6.59	3.97	7.50
H.M.O.W.	4.13	6.91	3.31	6.08	4.06	6.84	3.76	6.17

If we select from all the stations, of which there are forty available, the highest figures to be found in any of them we get the following result :—

HIGHEST AVERAGE FOR YEAR IN ALL STATIONS, EXCLUDING LONDON.

1933-34	1934-35	1935-36	1936-37
4.13	3.64	3.91	4.72

Salford, Regent Rd. Rotherham. Halifax, Wade St. Salford, Ladywell San.

HIGHEST MONTH FOR ALL STATIONS, EXCLUDING LONDON.

1933-34	1934-35	1935-36	1936-37
6.59	6.51	6.50	9.20

Leeds, Park Square. Sheffield. Halifax, Wade St. Manchester, Oldham Rd.

These figures speak for themselves. It will be seen that the London figures are comparable with the most highly sulphur polluted cities of which we have records. It is somewhat disturbing to find that of all the stations of which we have records in England, the highest average for the year during the period of observations was 5.60 mgms. of SO_2 per 100 sq. cm. per day at County Hall and the next highest was 5.05 also found at County Hall and after this was Salford, Ladywell Sanatorium with 4.72. These figures are averages for the whole year. Looking now at the highest recorded month during the whole of the available period, we find that in 1933-34, the County Hall figures

reached 9.42 and in 1936-37 11.90, whereas the highest monthly figure found in any other place was 9.20 at Manchester, Oldham Road.

Comparison with Past Years.

Deposit.

A series of tables are given in which Table 2 shows for the average of eight London stations the amount of deposit recorded each year from 1915-16 to 1936-37. The following Tables 3-10 give the same figures for the individual stations, as these bring out the variation between different parts of London.

Referring to Table 2, giving the average figures, you will see that a somewhat curious state of affairs is disclosed. In 1915-16, the total deposit from the air amounted to 415 tons per square mile, the sulphates deposited were 72 and the tar 4. There was a rapid improvement until 1921-22 when the total deposit fell to 284 tons, sulphates to 25, while tar had increased to 5. Looking now at the total deposit of impurity, we find little change between 1922 and 1936, in fact the amount recorded in these two years was exactly the same, that is 284 tons per square mile. There were variations in the interval between, but nothing very great. Sulphates show that there was an actual increase as between 1921-22 and 1936-37, while tar had altered very little, if anything a slight reduction.

The inference we may draw from this table is that for some reason, probably that the easiest things were done first, there was a very rapid improvement after the commencement of observations, but we appear to have been almost at a standstill for the last 15 or 16 years, with some deterioration from the sulphur pollution point of view. This is not a very satisfactory condition and shows that our efforts to clean the air should not be relaxed.

The individual stations shown in Tables 3-10 need not all be referred to, but it is noticeable that there is a greater improvement in some than in others. At Archbishops Park, for example, which unfortunately did not start observations until 1920-21, there has been little or no change except slight variations up and down from year to year, and this applies to the total deposit, the sulphates and the tar. Finsbury Park has also little improvement to show, in fact the total deposit during 1915-16 was rather less than during 1935-36, while the deposit of sulphates during 1935-36 was double that in 1915-16. Golden Lane, in the City, shows no improvement during the whole period from 1915-16 to 1934-35, in fact the total deposit, the sulphates have increased while the tar deposit has increased over five times. During the year 1933-34 the total deposit amounted to 632 tons per square mile, sulphates to 107 tons and tar 12 tons. Since then up till last year there has been an improvement as the figures in the table show.

Suspended Matter.

In Table 11, the figures for suspended impurity for five different London stations are given for the available years. These figures do not go back as far as the deposit gauge because the method of measurement, that is the automatic filter, was not available in the early days. However, looking at the available figures it is not advisable to sum these up for averages as in the case of deposit, but the different stations might be considered briefly and independently. Referring to the table, it will be seen that Kew shows on the whole a slight improvement, more marked in 1936-37 than in previous years. South Kensington also shows an improvement, whereas Victoria Street shows no appreciable change, in fact in 1936-37 it gave a higher figure than in 1923-24, the first available year. Westminster Bridge, that is at the County Hall, shows a little improvement, but not very regular, and for some as yet unknown reason the figures here are considerably lower than at Victoria Street or Westminster City Hall. In the case of the latter, for which only seven years are available, there has been on the whole an improvement, but not very much. The figures have fallen from 86 in 1930-31 to 65 in 1936-37.

In Table 12 is shown another way of examining the progress in cleaning the air, that is by counting the number of days on which there was a fairly thick smoke fog or haze. This is not to be considered as the days of dense smoke fog such as would be ranked as a "London particular," but rather milder than this. However, useful information can be obtained in this way and Table 12 shows the percentage of the days of observations which had a thick smoke haze. The figure is given for six London stations and for two other cities for comparison. Looking at the central London stations:—Victoria Street is not very different from Westminster City Hall, and the percentage of days with smoke haze range from 33 to 75 at Victoria Street and from 36 to 75 at Westminster City Hall. There has been a slight improvement during the last few years at all stations, but whether this is a meteorological effect or due to reducing smoke, is not certain. It will be seen from the table that the three years 1931 to 1934 are about the worst and that prior to this there was a gradual increase in most of the stations, and following it a reduction.

The Investigation into Atmospheric Pollution, with which I am concerned, has, in my view, as its chief function the production of a public opinion averse to having the air in which they have to live polluted, and this can only be done by bringing out, by such figures as I have given, the magnitude of the evil. The question is often asked "What is the remedy?" and it is a very pertinent one. The answer might be given that so far as industrial smoke is concerned there is at present no technical

difficulty in preventing it or at least reducing the quantity so that no nuisance would be produced. The real difficulty is to insure the use of correct methods of producing smokeless combustion. Unfortunately in some cities the domestic fire is the greater sinner and, as has been shown, the proportion of domestic to industrial smoke in London is of the order of 2.15 to 1. This does not necessarily hold good in other cities.

How is the domestic smoke to be prevented? There is only one known method at present and that is to burn a fuel which does not produce smoke. Without going into the reasons in detail, it may be taken that there is no domestic open fire which will burn soft bituminous coal without producing smoke. That is not to say that it is humanly impossible by continuous and careful stoking to prevent smoke in such a fire, but it is not practicable to do this. Hence the necessity for a smokeless fuel, and it is my opinion that no solution of the domestic smoke problem will be found until and unless the burning of smoky coal in our big cities is prohibited. There are at present available smokeless fuels, and a sufficient quantity could be made available if there was a demand for it.

TABLE 1.
PRESENT POSITION.

ANNUAL TOTAL IN TONS PER SQUARE MILE FOR 1936-37.			
	Total Solids.	Sul-phates.	Tar.
LONDON :—			
Archbishops Park...	322	43	5
S. Kensington			
(M.O.)	219	27	5
Finsbury Park	273	53	4
Ravenscourt Park...	210	32	4
Southwark Park ...	241	30	3
Golden Lane	261	39	7
Victoria Park	209	24	5
Wandsworth			
Common	172	22	2
Average of above 8			
Stations	238	34	4

TABLE 2.
AVERAGE OF 8 LONDON STATIONS.

DEPOSIT IN TONS PER SQUARE MILE (ANNUAL TOTAL).			
	Total Solids.	Sulphates.	Tar.
1915-16	415	72	4
1916-17	400	68	4
1917-18	379	60	3
1918-19	372	70	3
1919-20	346	53	3
1920-21	307	27	5
1921-22	284	25	5
1922-23	302	36	3
1923-24	288	33	2
1924-25	319	41	3
1925-26	264	32	3
1926-27	303	40	4
1927-28	316	30	4
1928-29	255	29	4
1929-30	272	35	4
1930-31	289	41	4
1931-32	281	41	4
1932-33	272	41	4
1933-34	315	45	5
1934-35	298	49	5
1935-36	284	43	4
1936-37	238	34	4

TABLE 3.
LONDON: ARCHBISHOPS
PARK.

DEPOSIT IN TONS PER SQUARE MILE (ANNUAL TOTAL).			
	Total Solids.	Sulphates.	Tar.
1920-21	354	41	6
1921-22	349	33	4
1922-23	329	45	4
1923-24	299	40	3
1924-25	404	55	4
1925-26	359	44	6
1926-27	407	47	4
1927-28	333	51	4
1928-29	263	38	4
1929-30	229	35	4
1930-31	304	41	5
1931-32	366	45	5
1932-33	325	42	5
1933-34	339	37	5
1934-35	399	43	7
1935-36	426	45	6
1936-37	322	43	5

TABLE 5.
LONDON: GOLDEN LANE.
DEPOSIT IN TONS PER SQUARE MILE
(ANNUAL TOTAL).

	Total Solids.	Sulphates.	Tar.
1915-16	444	76	2
1916-17	348	61	4
1917-18	388	58	3
1918-19	389	63	3
1919-20	341	49	2
1920-21	342	40	2
1921-22	349	32	2
1922-23	413	53	2
1923-24	417	57	2
1924-25	450	68	1
1925-26	431	57	1
1926-27	465	69	1
1927-28	582	73	2
1928-29	387	38	2
1929-30	383	41	4
1930-31	400	46	7
1931-32	297	44	5
1932-33	337	46	5
1933-34	632	107	12
1934-35	525	98	11
1935-36	286	37	10
1936-37	261	39	7

TABLE 4.
LONDON: FINSBURY PARK.

DEPOSIT IN TONS PER SQUARE MILE (ANNUAL TOTAL).			
	Total Solids.	Sulphates.	Tar.
1915-16	384	48	5
1916-17	420	70	3
1917-18	445	81	3
1918-19	488	94	4
1919-20	323	54	3
1920-21	227	22	3
1921-22	217	18	3
1922-23	236	28	3
1923-24	228	25	2
1924-25	292	36	3
1925-26	219	24	4
1926-27	256	30	4
1927-28	278	31	5
1928-29	235	26	4
1930-31	232	27	4
1931-32	235	26	5
1932-33	228	28	5
1933-34	368	62	5
1934-35	383	87	5
1935-36	397	97	4
1936-37	273	53	4

TABLE 6.
LONDON: RAVENSCOURT
PARK.

DEPOSIT IN TONS PER SQUARE MILE (ANNUAL TOTAL).			
	Total Solids.	Sulphates.	Tar.
1915-16	358	64	3
1916-17	441	79	6
1917-18	376	43	5
1918-19	344	63	2
1919-20	—	—	—
1920-21	271	29	6
1921-22	213	21	3
1922-23	236	29	3
1923-24	242	23	3
1924-25	216	29	3
1925-26	280	23	3
1926-27	—	—	—
1927-28	217	28	4
1928-29	297	23	4
1929-30	338	67	4
1930-31	452	104	4
1931-32	463	102	4
1932-33	462	105	5
1933-34	—	—	—
1934-35	237	63	2
1935-36	288	47	4
1936-37	210	32	4

TABLE 7.
LONDON: SOUTH
KENSINGTON.

DEPOSIT IN TONS PER SQUARE MILE
(ANNUAL TOTAL).

	Total Solids.	Sulphates.	Tar.
1915-16	406	62	3
1916-17	347	44	2
1917-18	332	45	4
1918-19	—	—	—
1919-20	253	21	5
1920-21	338	27	9
1921-22	256	19	5
1922-23	325	28	7
1923-24	307	31	5
1924-25	327	33	6
1925-26	253	27	5
1926-27	300	40	5
1927-28	289	35	5
1928-29	255	28	4
1929-30	224	25	4
1930-31	225	27	4
1931-32	225	27	4
1932-33	189	22	7
1933-34	187	26	5
1934-35	254	30	5
1935-36	223	32	4
1936-37	219	27	5
1929-30	278	32	4

TABLE 9.
LONDON: VICTORIA PARK.
DEPOSIT IN TONS PER SQUARE MILE
(ANNUAL TOTAL).

	Total Solids.	Sulphates.	Tar.
1915-16	411	83	2
1916-17	—	—	—
1917-18	—	—	—
1918-19	—	—	—
1919-20	233	45	1
1920-21	238	28	3
1921-22	248	21	3
1922-23	240	34	2
1923-24	230	29	2
1924-25	258	39	2
1925-26	217	31	2
1926-27	207	30	2
1927-28	205	27	2
1928-29	180	23	2
1929-30	233	26	3
1930-31	229	26	4
1931-32	192	22	2
1932-33	204	27	3
1933-34	221	22	3
1934-35	220	24	3
1935-36	219	29	2
1936-37	209	24	5

TABLE 8.
LONDON: SOUTHWARK PARK.

DEPOSIT IN TONS PER SQUARE MILE
(ANNUAL TOTAL).

	Total Solids.	Sulphates.	Tar.
1915-16	563	89	4
1916-17	518	85	3
1917-18	520	88	1
1918-19	503	128	3
1919-20	471	91	2
1920-21	363	30	8
1921-22	317	26	8
1922-23	318	38	3
1923-24	304	27	2
1924-25	284	33	2
1925-26	231	27	3
1926-27	252	37	3
1927-28	325	38	7
1928-29	298	32	6
1929-30	274	32	8
1930-31	251	31	3
1931-32	249	29	3
1932-33	229	27	4
1933-34	238	31	3
1934-35	213	24	3
1935-36	278	35	3
1936-37	241	30	3

TABLE 10.
LONDON: WANDSWORTH
COMMON.

DEPOSIT IN TONS PER SQUARE MILE
(ANNUAL TOTAL).

	Total Solids.	Sulphates.	Tar.
1915-16	276	—	2
1916-17	—	—	—
1917-18	—	—	—
1918-19	—	—	—
1919-20	—	—	—
1920-21	247	20	7
1921-22	270	22	3
1922-23	242	25	2
1923-24	225	27	1
1924-25	274	25	1
1925-26	176	31	2
1926-27	183	24	2
1927-28	236	27	3
1928-29	175	22	2
1929-30	166	20	2
1930-31	175	22	2
1931-32	179	24	2
1932-33	161	26	2
1933-34	176	23	2
1934-35	151	23	2
1935-36	180	25	2
1936-37	172	22	2

TABLE 11.

CONCENTRATION OF SOOTY SUSPENDED MATTER.
AVERAGE VALUES FOR WINTER MONTHS IN mgms./100 m³.

Year.	LONDON :—	Kew Observatory.	South Kensington.	Victoria Street.	Westminster Bridge County Hall.	Westminster City Hall.
1923-24	38	72	55	52	—
1924-25	35	59	45	48	—
1925-26	30	67	53	32	—
1926-27	23	48	51	29	—
1927-28	18	62	69	—	—
1928-29	32	64	64	49	—
1929-30	17	58	—	32	—
1930-31	21	57	62	54	86
1931-32	32	67	91	47	74
1932-33	23	55	80	46	67
1933-34	35	39	79	43	93
1934-35	21	39	42	37	74
1935-36	29	53	58	40	58
1936-37	15	31	69	38	65

TABLE 12: SHOWING INCIDENCE OF THICK SMOKE HAZE.
AS % OF TOTAL NO. OF DAYS.

Year.	South Kensington.	Victoria Street.	West- minster Bridge.	West- minster City Hall.	Green- wich.	Kew Obser- vatory.	Stoke-on- Trent.	Coventry.
1923-24	..... 47	56	38	—	—	13	65	—
1924-25	..... 49	33	—	—	—	10	59	—
1925-26	..... 74	49	—	—	—	13	27	—
1926-27	..... 18	40	7	—	—	6	46	—
1927-28	..... 47	53	—	—	—	8	33	—
1928-29	..... 41	67	34	—	—	20	27	—
1929-30	..... 37	—	11	—	—	5	63	—
1930-31	..... 31	45	33	75	—	6	7	—
1931-32	..... 45	75	23	60	—	21	72	3
1932-33	..... 36	70	22	58	—	10	67	2
1933-34	..... 23	71	20	74	—	20	73	5
1934-35	..... 15	33	10	61	—	8	80	12
1935-36	..... 37	44	15	36	28	16	76	17
1936-37	..... 8	55	12	55	42	3	66	6

**Address by Mr. E. H. Keeling, M.C., M.P. on
Moving the Resolution.**

Almost the first step of the National Smoke Abatement Society, on moving its office from Manchester to London, was to call this conference on smoke abatement in Greater London. Now I am not sure whether the removal from Manchester last year was a compliment to London or an insult, but at any rate I should like to congratulate the Society on taking such early steps to get down to business in its new home. It is what we should have expected from a body which has already done much for smoke abatement.

Nobody who lives in London, nobody who visits London in winter, even if he comes from Manchester, can doubt the crying need for further action. Smoke is bad for health. It is possible to exaggerate its potency in causing actual disease, though that may be considerable, but can any one doubt that if Londoners could all breathe a pure atmosphere, could all see the sun shining at times when its rays are withheld, not by God but by the action of man, the effect on their physique, energy and cheerfulness would be as great an advantage to the nation as the improvement of a few by physical training? The air we breathe ought to be as pure as the water we drink. And what of the effect of smoke on vegetation? 500 years ago, as we all learnt at school, roses both white and red grew in the Temple. They do not grow there now. Consider also the immense material saving to be made. Vast sums are spent in London on cleaning away the pollution, and on repairing the damage, caused by smoke. Is it not good business to try and remove the cause of this damage?

We are sometimes told that the smoke problem in London is getting smaller every year, and will in time solve itself. As Dr. Owens told you, the figures do not bear out that contention. I happen to work at the Air Ministry, which is, as you know, the office of the Director of Meteorological Observation, otherwise known as the Clerk of the Weather, Sir George Simpson. Sir George has got out some figures for me which show that 50 years ago the pollution did begin to get less, but about 15 years ago progress stopped. In the 10 years ending in 1890 Central London had only one-third of the winter sunshine enjoyed at Kew. By 1920 the proportion had improved to half. And to-day it is still only half. Sir George added with a touch of pride that he was not responsible for the stagnation, for he has not a single coal fire in his own house!

Dr. Owens drew an illuminating comparison (if that adjective is not out of place) between London and other British cities. He showed that the air breathed by Londoners is as much polluted by sulphur and sooty matter as any city in Great Britain.

This fact should put us Londoners to shame and stir us into action.

It is action which I have the honour to propose. I am going to move that steps should be taken to constitute an Advisory Smoke Abatement Committee for Greater London, and I am going to ask the representatives of the various local authorities here to use their best endeavours to that end.

Already a number of such advisory committees exist in various regions of the provinces.

An advisory committee will have no statutory powers, and no statutory duties, and that means it can be run on extremely economical lines: indeed the cost will be infinitesimal. It also means that there will be no compulsion to join the Committee, though I hope that all local authorities *will* join. Can any district in London say that no unnecessary smoke is created *there*, or that it does not suffer from smoke created in any other district?

What can a regional advisory committee achieve? There was a discussion on this matter at the Conference of the N.S.A.S. at Leeds in October last, at which members of the provincial committees to which I have referred described their work. It seems to have been the general opinion that they can do a good deal.

First of all, the mere existence of such a Committee, if it does not hide its light under a bushel, has an effect on public opinion. It creates a public demand for action.

Secondly, it can do much by persuasion—the traditional English method of reform. It can supply local authorities with expert advice, and with information as to the results of research. By its influence it can promote a more uniform administration of the law, and a standardised method of taking observations. By encouraging local authorities to include smoke abatement in health week propaganda it can stimulate the education of the public.

Thirdly, such a Committee can organise the training of stokers, if employers will co-operate. It is to their interest to co-operate, for such training often reduces fuel consumption.

In London, however, industrial smoke is not the main enemy. Dr. Owens told us that the domestic fire is responsible for more than two-thirds of what Mr. Julian Huxley has called the air sewage of London. And when one remembers that the other one-third includes all the smoke produced by offices as well as by factories, one appreciates what a small share of London smoke is caused by industry, and how great a sinner the ordinary householder is.

I do not wish to minimise the pollution caused by fires in offices. Undoubtedly one of the greatest offenders is H.M. Government. Dr. Owens told us that the highest concentration

of suspended impurity in the air of London is found in Victoria Street—and the next highest, in the Westminster City Hall in Charing Cross Road. Now it is a most significant fact that in the half mile between those two places most of the old Government offices are situated. There the open coal fire reigns supreme. Go down to Whitehall on any winter morning about nine o'clock, when the charwomen are lighting the fires, and you will see what the Government is doing to the atmosphere of Westminster. I read the other day in "The Times" a suggestion that an easy means of preventing an enemy in the air from identifying particular objectives would be to create a smoke screen over the whole of London. It would seem that by creating a specially conspicuous smoke cloud over Whitehall the Government is enabling an enemy to identify that area and is thus pointing the way to its own destruction! But to be serious, is it not high time that the coal fires of London offices were replaced by smokeless fuel or central heating? Surely the Government should set an example to the rest of London.

As to the domestic fire, our hope lies, as Dr. Owens said, in promoting the consumption of gas, electricity and fuel which does not produce smoke. In new houses and offices, where an open grate is provided at all, every effort must be made by propaganda and education to encourage the installation of a type suitable for burning coke or smokeless fuel, and to put coke, etc. on sale in small quantities. Local authorities are becoming such large landlords that to a considerable extent the remedy is in their own hands. As regards privately owned houses, I would like to see legislation introduced enabling local authorities to charge a somewhat lower rate to householders who create no smoke, or to give grants for the conversion of old grates to new. But that is wandering from the function of a Regional Committee.

Ladies and Gentlemen, I hope I have said enough to convince you that the evil is great and that an Advisory Committee could do much to combat it. I beg to move: That this meeting is of the opinion that steps should be taken to promote the formation of an Advisory Regional Smoke Abatement Committee for London and Greater London, and requests the National Smoke Abatement Society to report to the Authorities concerned, asking them to agree in principle to the proposal, and to be represented at a further meeting to be convened for the purpose of establishing such a Committee.

**Address by Mr. W. A. Damon, Chief Inspector of Alkali,
&c., Works, representing the Minister of Health.**

In 1842 a meeting was held in Leeds to draw attention to various inventions for the prevention of smoke. That the matter, even in those days, was a highly controversial subject is shown by this extract from a circular announcing the meeting :

“Wm. Beckett, Esq., M.P. for Leeds, will take the chair : he will give each inventor an opportunity of explaining his apparatus : afterwards questions may be asked. It is not, however, proposed to allow inventors to question each other as this might lead to personal remarks being made.”

Fortunately this meeting is not immediately concerned with inventions for smoke abatement. Even if it were so, I feel sure that the protagonists would recognise in each other public benefactors and would not so far forget themselves as to make innuendos likely to lead to disorder.

The matter of smoke abatement is one with which the Ministry of Health is closely concerned and one, moreover, in which the Minister takes a personal interest.

Although the Ministry has, for many years been closely associated with the work that has been done from a variety of angles with the object of reducing atmospheric pollution, its statutory functions as regards smoke are limited to matters such as the following :—

- (1) Confirmation of byelaws. P.H. Act, 1936, 104 ; P.H. (London) Act, 1936, 151.
- (2) Regulating powers regarding investigation and research by local authorities and other bodies. P.H. Act, 1936, 105 ; P.H. (London) Act, 1936, 153.
- (3) Extension or curtailment of the list of exempted processes. P.H. Act, 1936, 109.
- (4) Setting up and regulation of united districts and joint boards. P.H. Act, 1936, 6-10.

(This refers to executive and not advisory bodies.)

Under the Public Health (London) Act, the byelaws are for the London County Council to make and for the sanitary authorities to enforce. There is no exemption of processes in London. In London, the County Council has some special powers and functions which outside county councils do not possess. Section 152 gives specific power to the Minister to acquire information from the local authorities. I do not suggest that authorities in London are more secretive than those outside, but there the provision is !

The duty of enforcing the law relating to smoke rests entirely with the local authorities. Enforcement does not necessarily imply prosecution: indeed, we all know that the better way is to encourage means of smoke abatement, the adoption of which will reduce liability of offending against the provisions of the Act. In order, therefore, to secure a satisfactory administration of the law, local authorities need the assistance and advice of competent smoke inspectors.

The sources of smoke can be roughly grouped under three headings:

- (1) Smoke emitted from domestic chimneys.
- (2) Smoke emitted from industrial chimneys.
- (3) Smoke emitted otherwise than from chimneys.

Domestic smoke is not as concentrated as that from industrial chimneys but it is more tarry and it constitutes a very large (many people consider it by far the largest) contributor to atmospheric pollution, although the amount of coal used for domestic purposes is estimated at less than one-fourth of the total consumption. It is outside the law but improvement must follow the increasing use of gas, electricity and solid smokeless fuel for domestic heating. The Fuel Research Board is playing its part in carrying out work in connection with the manufacture of semi-coke and on the possibilities of smokeless combustion of raw coal. Every householder can do his or her bit towards reducing atmospheric pollution, but I fear that Sir David Milne Watson was right when he remarked recently that smoke abatement was a cause with no opponents in theory but comparatively few exponents in practice. Here surely is a case for organised and widespread propaganda which can best be effected by a joint committee.

Smoke from industrial chimneys includes that from steam raising and from furnaces for other process work. The former is merely a matter of the intelligent operation of properly constructed plant of adequate capacity for the work it is required to perform. May I plead that steam raising should be more generally regarded as a skilled job to be entrusted to skilled men? It is not merely a matter of shovelling coal and raking out ashes. Stokers should be encouraged to attend classes in the technique of fuel combustion and those who succeed in gaining certificates of proficiency should be rewarded by increased pay. The organisation of classes at suitable centres would doubtless be one of the functions of a regional committee.

In mentioning smoke emitted otherwise than from chimneys, I had in mind principally the problem of burning colliery spoil-banks to which the Ministry has in the past few years devoted much attention. Fortunately, this particular form of nuisance is not prevalent in the London area.

As regards industrial smoke generally, local authorities possess the power to seek penalties for an emission which is a nuisance. Where black smoke is concerned, and especially if there is a byelaw, the procedure is relatively simple. In the case of smoke other than black, the law allows a best practicable means defence and the fear of being unable successfully to rebut such a defence seems to deter many authorities from taking action. This clearly implies the desirability of employing expert smoke inspectors, whose usefulness in Court proceedings is unquestionable, although their greater scope would lie in their ability to discuss technicalities and to co-operate with industry, the claims and real difficulties of which should receive sympathetic consideration. From my own experience, I am convinced that with very few exceptions, industrialists are as anxious as anyone else to mitigate the smoke evil and that far better results can be obtained from constructive co-operation than by means of threats and imposition of fines.

The possibility of employing a well-trained staff of smoke inspectors is, to my mind, one of the chief arguments in favour of a combination of local authorities.

Personally, I favour "statutory" committees to which the constituent authorities have voluntarily delegated their powers in the matter of smoke, but I understand that legal difficulties make it hardly possible to set up a joint committee of authorities both inside and outside London possessing full statutory powers. It is up to London of all places, as a matter of local and international pride, to sweep away its reputation for griminess, and a joint advisory committee charged with such functions as the constituent authorities care to delegate to it, could operate very usefully in correlating the work of its constituents, in circulating information, in ensuring uniform administration, in maintaining an advisory service of experts, in propaganda work and in securing greater facilities for the training of boiler and furnace attendants.

In 1936, the Regional Committees sent representatives to confer together with the Alkali Inspectors at the Ministry of Health. A most instructive discussion on the "burning questions" of the day eventuated during which much useful information was exchanged. It is sincerely hoped that further similar conferences will be held and that London will be represented in the future. It is obviously more practicable for the Ministry to deal with a Committee representing a consolidated region than with a number of individual authorities, which may hold conflicting views.

Mr. Keeling has set forth the objects at which he thinks a joint committee should aim and I am glad that he has done so very clearly because I feel that it is vitally important for a committee to apply itself to a definite objective, keeping it continually in view so as to avoid the danger of losing itself in a train of

side issues. Another factor vital to the success of a committee is that it should enjoy the confidence and practical support of its constituents. Smoke, unfortunately, has no respect for boundaries, and it is therefore essential that the constituent authorities should recognise their mutual responsibilities. It is no use for an authority to appoint a representative and then take no interest in the reports that he brings back. Enthusiasm at the birth of a committee is good but it is not enough. A true conception of all the difficulties and a dogged determination to surmount them is necessary. If I may use a homely metaphor which seems apt to the business in hand, you want to make a good fire built up on sound knowledge and experience, but you must avoid the use of excessive hot air lest local overheating should lead to a loss of efficiency. If this Conference will supply the fuel, the National Smoke Abatement Society can be trusted to assist with the skilled stoking and the Ministry of Health will help, too.

A new committee may conclude that certain omissions and nuisances were made in connection with the former committee. If so, benefiting from those previous experiences, it can learn much from other established committees and rise like a phoenix from the ashes of its predecessor.

In conclusion, it appears that the problem of smoke can be successfully combated only by the resolute and persistent activity of local authorities preferably in combination and with the assistance of trained staff, by co-operation with and with the goodwill of industry and by extensive propaganda.

I have to furnish a report of to-day's proceedings to the Minister of Health, who will be greatly interested to know the result of your deliberations and I am instructed to say that any assistance which the officers of the Ministry can properly afford you is entirely at your disposal.

**Address by Mr. W. R. Hornby Steer, M.A., LL.B., F.R.San.I.,
L.C.C., Standing Counsel to the Society on
Seconding the Resolution.**

I rise to second the resolution on the paper which has been proposed by Mr. Keeling. It is to this matter that I shall direct my few observations. The evil of smoke pollution is admitted. It is recognised that we have the knowledge necessary to relieve in large measure the injurious effects of this nuisance. Much useful work in this direction has been done by local authorities; but having regard to the admitted facts of the situation further action is necessary. The question before us in the resolution is in effect this: Would the formation of a joint advisory committee as suggested be action which is likely to result in an appreciable reduction of the evil? In my judgment it undoubtedly would be so, and I heartily commend the resolution to the Conference. The fact is that Londoners are still not sufficiently regional minded. This was not always the case. I recently had cause to refer to a comparatively early Act of Parliament—the Smoke Nuisance Abatement (Metropolis) Act, 1853. The members of the Conference well know this was not only before the creation of the London County Council but also before the formation of the Metropolitan Board of Works. It is, therefore, interesting to note that the area affected by the Act was defined by means of a schedule containing a number of parishes, including all the then built-up areas and also a number of which must at that time have still maintained their rural character. The area was approximately that of the present administrative county; but it is to be noted that at that time it included the greater London of that day. Since then we have not shown such a regional attitude. This is, in some measure, due to Parliament which has enacted that the inner part of our town is in regard to smoke nuisances subject to one statute while the outer part is in this respect subject to another, and I suggest that this has had the effect of causing us in this respect to overlook the regional character of greater London. There are a number of instances where it has been found necessary for the provision of public services to be based on an area greater than that of the administrative county. I would, in passing, mention those of Transport, Water and Electricity. These are, of course, services controlled by bodies with executive powers. The resolution before you asks only for an advisory committee. Example of Joint Advisory Committees in this area are the Greater London Standing Conference on Regional Planning, the London Regional Advisory Council for Juvenile Employment and the London and Home Counties Traffic Advisory Committee. In these cases it has been found necessary to form such Committees, and I suggest that at least an equally strong case exists for the

formation of a Regional Advisory Committee to deal with the problems of smoke. Previous speakers have indicated the useful ways in which such a committee could benefit greater London; and there is no need for me to emphasize this aspect of the matter.

It must not be overlooked that in appointing members to such a committee the appointing authority are not being committed to any action which they cannot control and they are not being committed to any action from which they cannot withdraw.

Such a committee is not an executive committee, but is a deliberative committee. It can do no harm—it may do much good.

The cost involved is in the circumstances comparatively negligible, but the gain to the community may be very great. The formation of such a committee may make demands on the time and energy of those who are working for success in this direction, but I suggest to the conference that this effort will be well worth while inasmuch as it is likely to advance to a considerable degree the health and happiness of the people of greater London.

For these reasons I confidently recommend the conference to adopt the resolution before them.

AUTHORITIES REPRESENTED AT THE CONFERENCE.

The Ministry of Health.

The County Councils of :

London.

Essex.

Middlesex.

The City of London.

The City of Westminster.

The Metropolitan Boroughs of :

Battersea.

Bermondsey.

Bethnal Green.

Camberwell.

Deptford.

Finsbury.

Fulham.

Greenwich.

Hackney.

Hammersmith.

Hampstead.

Holborn.

Islington.

Lambeth.

Lewisham.

Paddington.

Poplar.

St. Marylebone.

St. Pancras.

Shoreditch.

Southwark.

Stepney.

Stoke Newington.

Woolwich.

The County and Municipal

Boroughs of :

Acton.

Barking.

Beckenham.

Brentford and Chiswick.

Ealing.

Edmonton.

Epsom and Ewell.

Finchley.

Heston and Isleworth.

Ilford.

Leyton.

Malden and Coombe.

Mitcham.

Southall.

Southgate.

Twickenham.

Wembley.

West Ham.

Willesden.

Wood Green.

The Urban Districts of :

Carshalton.

Chingford.

Chislehurst and Sidcup.

Dagenham.

Enfield.

Hayes and Harlington.

Merton and Morden.

Uxbridge.

Waltham Holy Cross.

**NATIONAL SMOKE
ABATEMENT SOCIETY**



**PROCEEDINGS OF THE LONDON
CONFERENCE • 1943**

**MEASURES FOR SMOKE PREVENTION
IN RELATION TO PLANS FOR
POST-WAR RECONSTRUCTION**

**Price :
One Shilling**

The National Smoke Abatement Society

President : Will Melland, M.A., J.P.

Hon. Treasurer : Sir Lawrence Chubb

Chairman : Charles Gandy

General Secretary and Editor : Arnold Marsh, M.Sc., Tech., M.Inst.F.

Chandos House, Buckingham Gate,
Westminster, S.W.1.

'Phone : ABBey 1359

Scottish Branch : City Chambers, Glasgow

North-Western Branch : 1b, Cooper St., Manchester 2

*Full information about the Society, particulars of membership,
and Annual Report, etc., will gladly be sent on request.*

PROCEEDINGS

of the

ELEVENTH ANNUAL CONFERENCE

of the

National Smoke Abatement Society

held at the Caxton Hall, London, S.W.1,
on 5th November, 1943

MEASURES FOR SMOKE PREVENTION IN RELATION TO PLANS FOR POST-WAR RECONSTRUCTION

CONTENTS

	Page
ADDRESS—"Unholy Smoke," by Mr. Clough Williams-Ellis	3
STATEMENT on behalf of the Executive Committee	6
DISCUSSION :	
Mr. James Law	8
Councillor J. Coot	8
Miss Elizabeth Denby	9
Miss Caroline Haslett	9
Dr. R. Lessing	9
Mr. V. W. Dale	9
Dr. J. Johnstone Jervis	11
Mr. J. W. Beaumont	12
Mr. F. J. Redstone	13
Councillor Mrs. Alderson Horne	14
Mr. Leslie Hardern	14
Alderman J. J. Milton	15
Mr. Edward Robinson	15
Councillor the Rev. R. Burges	15
Dr. G. E. Foxwell	15
Councillor Mrs. A. A. Barnes	18
Mr. John Charrington	18
Mr. A. E. Margolis	19
Mr. J. W. Young	20
Mr. T. E. Birtwisle	21
Mr. James Law	22
Mr. Thos. M. Ashford	23
RESOLUTIONS	24

LOCAL AUTHORITIES REPRESENTED AT THE CONFERENCE

Acton
Barnes
Batley
Battersea
Beckenham
Bilston
Birmingham
Brighton
Bristol
Carshalton
Camberwell
Cardiff
Castleford
Chelsea
Chester-le-Street R.D.C.
Chislehurst and Sidcup
Coatbridge
Dagenham
Dudley
Durham R.D.C.
Easington R.D.C.
East Ham
Ebbw Vale
Edmonton
Epsom and Ewell
Essex C.C.
Feltham
Finsbury
Fulham
Glasgow
Greenwich
Halifax
Hammersmith
Harrow
Hayes and Harlington
Holborn
Hornsey
Houghton-le-Spring
Huddersfield
Ilford
Islington
Kingston-upon-Hull
Lambeth
Leeds
Lincoln
London, City of

London County Council
Luton
Manchester
Merton and Morden
Middlesex C.C.
Newport
Oldham
Orpington
Port Glasgow
Paddington
Richmond (Surrey)
St. Helens
St. Pancras
Salford
Sheffield, Rotherham and District
Smoke Abatement Committee
Smethwick
Southall
Staines
Stepney
Stoke Newington
Sunderland
Sutton and Cheam
Tottenham
Twickenham
Urmston
Uxbridge
Walsall
Waltham Holy Cross
Walthamstow
Wandsworth
Wanstead and Woodford
Warrington
Watford
Wednesbury
Wembley
West Bromwich
West Ham
Westminster
Whiston R.D.C.
Widnes
Wimbledon
Wood Green
Woolwich
Wrexham



MEASURES FOR THE PREVENTION OF SMOKE IN RELATION TO PLANS FOR POST-WAR RECONSTRUCTION

Morning Session

Chairman: Sir Lawrence Chubb

In his opening remarks the Chairman welcomed the members and delegates attending the first conference of the Society to be held since the war began. He stated that the author of the address to be read, Mr. Clough Williams-Ellis, unfortunately found it impossible to be present in person, but that he had kindly written his paper. He called upon the Secretary to read this to the meeting.

UNHOLY SMOKE

By Clough Williams-Ellis
M.C., F.R.I.B.A.

FUNNY, you would think that by now, the last word about smoke pollution *must* have been said, but quite clearly it hasn't been, either by me or by anyone else, for if it had, that magic word would have exorcised for ever the gloom-demon that still plagues us.

True, we also still put up with all manner of other perfectly avoidable follies and nuisances that a little more commonsense, co-operation and determination could readily abolish, but I doubt whether there is any reform so generally recognised as necessary, so obviously and quickly feasible and that, further, would yield such immense and immediate improvement in return for a short, sharp and determined "Blitz," as that against our centuries old oppressor, smoke.

Grumble, oh, yes, we *grumble* all right, and have done increasingly for three or four centuries at least, but we

have done little more than just shrug our shoulders and say "Filthy nuisance," accept it as inevitable (as we long so accepted plague and famine until we realised that they *weren't*), still adding our own individual contribution to the life-denying pall with the feeling that where all are so foolishly selfish, what could one man's virtue signify?

That may not be a highly moral attitude to adopt, but it is a very natural and commonsensical one. For this is a battle that cannot be won by the single combat of heroes but only by a peoples' army, led by heroes certainly, but itself filled with zeal and a conviction that its cause is good.

It is that army that this society has been steadily recruiting over many years past; it has conducted a long-drawn guerilla warfare against the enemy, it has won various quite important engagements, but it has by no means won the *war*. That, I am convinced, will only be won by a major frontal assault with overwhelming forces at a favourable time. The most favourable time for winning an anti-smoke war will be almost immediately after the anti-fascist war, and it is for that zero hour that our maximum forces must be ready, which is what we are here to do something immediate about this very day.

Coal-smoke abatement must figure prominently in any adequate planning programme; such programmes are being formulated and crystallised *now*, and it is for this Society and all of you, its friends, to see that due place is given to what especially concerns us reformers, though it of course concerns every man, woman and child in Britain no less.

I cannot pretend to be fully up-to-date with the day-to-day activities of all the beneficent bodies to which I belong, and perhaps the Smoke Abatement Society has already made effective representations to such other bodies and Government Departments as are, or should be, most immediately concerned with our humane and civilised aims. Mark you, I said effective, and no representations can be called that unless and until they have in fact had the effect actually intended, which I take to be action resulting (eventually) in the realisation of those aims.

It so happens that I am pretty intimately involved on a good many sectors of the far-flung planning front, but I am not at present conscious of anything like sufficient stress being laid on this smoke question. That would seem to suggest that something further is necessary—some short sharp factual and statistical broadside or broadsheet giving well authenticated evidence that cannot be challenged, scientifically vouched for and supported by those whose authority as expert witnesses must command official attention. In a vague sort of way everyone knows that smoke is a harmful nuisance that no really self-respecting and fully civilised community would continue to tolerate—they will agree to all that I say—but as we have seen, it is not enough. They know it is “bad,” but we have failed I think to make them realise *how* bad, and that’s just what well tabulated statistics would do.

All can understand that the emission of smoke is obviously wasteful and extravagant but they probably (and rightly) reason that it will cost money as well as effort to abate the evil. What most of them *don’t* realise is that on a justly calculated balance sheet the gain in money alone would vastly outweigh the expenditure, whilst if human welfare as a whole could be as closely assessed, the case for reform—our case—would be quite unanswerable.

We—the elect—of course know that, and I believe it only needs a single sheet of foolscap carrying just the right words and figures to bring equal conviction to everyone else who can read and reason.

Not, of course, that the mere issue of such a proclamation or manifesto or whatever, would of itself and instantly

convert everyone to our own view, though it be the only sane one, for even truth and reason, even plain common-sense, needs salesmanship in this nonsensical world of ours, as Shaftesbury’s fight for the Factory Acts and Willets for Daylight Saving sufficiently remind us.

But even when we have got the legislation that we want and that is long overdue, that isn’t the end of our job by any means—far from it. Plenty of excellent and well-intended legislation has got onto the statute book, lots of good bye-laws have been adopted, that have in fact failed largely of their purpose simply because they have never been actively implemented, chiefly because public opinion has not been sufficiently strongly behind them. I always have a sneaking hope that every body to which I belong may one day cease to be necessary through achieving the object for which it was founded. That may yet be the happy fate of some, but never of this society.

First we must get our National Code—a Chimney Code as clear and compelling as the Highway Code, but then, and for ever after, we shall need to be on the alert to see that its provisions are duly observed. We shall no doubt need to institute competitive regional “Clean the Skies” weeks like “Safety First” weeks or Rat Weeks, and why not a National Badge scheme, where the public is encouraged to buy only (or preferably) such products as carry a stamp certifying that the manufacturers’ works have been duly inspected and approved as conforming to the standard of cleanliness as regards smokelessness required of those thus favourably distinguished?

The pollution of water that *may* be drunk by human beings is very properly considered a highly anti-social action and it is odd indeed that the poisoning of the air that all *must* breathe should be regarded so much more lightly.

Maybe, you will expect me, as an architect, to be especially vehement about the disastrous effects of smoke upon buildings. Well, of course, smoke is quite literally our *bête noire*.

It coats our buildings with soot and a bituminous deposit which ruins the mouldings, and not content with that, erodes our projections til they are apt to look more like decayed teeth than

architectural embellishments.

The Ministry of Health Committee on Smoke and Noxious Vapours Abatement some 20 years ago calculated that six million pounds worth of fuel a year is wasted in England on the production of worse than useless smoke. This was the mere waste of coal, and did not include the cost of extra washing which smoke causes in every town household, or the damage to agriculture, buildings and health. What the calculation would be to-day I cannot even guess.

Experts, factory owners, heating engineers and so forth, seem agreed that smoke prevention is not only possible, even in England, but might well be directly profitable. There are a great many devices on the market for the prevention of industrial smoke; under one system twin boilers are used and coal is burned in one and coke in the other, the coal smoke being blown across the incandescent coke and consumed. In another an oil spray is forced across the top of the fire, and of course now there are the mechanical stokers.

Some, however, maintain that all that is needed are proper training and shorter hours for human stokers. This has certainly been the finding elsewhere. Stoking is a skilled job, but in England, at any rate, the stokers—all except the head men—are often completely unskilled. They work very long hours, moreover, and are naturally tempted to stoke seldom and excessively, with the natural result that their spasmodic ministrations are proclaimed by billowing clouds of poisonous smoke.

Of course apart from the increasing use of gas and electricity, one of the most hopeful prospects in the clean air campaign is the probable wide adoption of "District Heating," either by steam or hot water—an exceedingly economical modern technique of central servicing already well tried out in Russia and America and obviously the thing for our more densely built-up city areas.

Unfortunately there seems to be no limit to the squalor that humanity will put up with in its ruthless, joyless, industrial towns, but there is a quite definite limit to the pollution of the air and the denial of sunlight below which life itself is not only prejudiced

but actually endangered. Thus quite apart from any reasonable human desire to live a little less ungraciously than is possible in the nastier of our towns, the very urge towards mere biological survival as an animal is forcing people out into the surrounding country.

In so far as the country is sought for its own delights, the instinct is clearly right and laudable; but in so far as it is colonised by refugees fleeing from intolerable towns, who have no natural instinct for country life, but who elect to live there as it were negatively and under protest, for the sake of their own and their children's bodily and spiritual health, the movement is calamitous.

The social and cultural amenities of a civilisation can only be enjoyed to their full in a community—a community of a certain size and compactness, that is, in a town; and no matter to what extent transport and communications may be improved, the towns still remain essential to civilisation and the good life.

Thus the existence of smoke has obviously an indirect as well as a direct effect in the progressive destruction of the countryside and is a chief agent in the failure of our towns to provide what only they could provide, and that is optimum conditions for fully civilised living.

Even a generation ago, even a decade ago, we were in nothing like so strong a position as we are to-day to press for smoke abatement on a really drastic scale.

Of course a better educated public opinion is now strongly with us, thanks largely to our own unflagging educative efforts, but, even more potent, technological advances have lately been such that our demands, once regarded as amiably impracticable, are now accepted as just plain commonsense and entirely in line with the most enlightened and up-to-date industrial practice, where fuel efficiency is as much a matter of pride as of profit and where a foul aerial effluent from a chimney is considered as wasteful and anti-social as the contamination of a river by foul effluents from a sewer.

There is a Pure Rivers Association that has taught better manners to sewers. We, teaching civilised deportment to chimneys, are its big brother

of the skies. We are allies, and until we have together won our war on all fronts—

“The dream of London white and clean,

The clear Thames bordered by its gardens green.”

will remain a dream, and no more.

So to Hell with all smoke—where it belongs ! Forward !

The paper was received with acclamation and it was proposed by Mr. Charles Gandy, and unanimously agreed, that an expression of the cordial thanks of the meeting be forwarded to Mr. Williams-Ellis for a brilliant contribution.

The Chairman then called upon Mr. Gandy, as Chairman of the Executive Committee, to present the following statement on behalf of the Committee.

STATEMENT ON BEHALF OF THE EXECUTIVE COMMITTEE

IN many diverse respects the plans now being drawn up for post-war reconstruction and development—townplanning, housing, new building, industrial re-equipment, and fuel utilisation—create a unique opportunity for the inclusion of measures that will either prevent smoke and other forms of air pollution or provide the means for their progressive abolition. Unless, in good time, the possibilities of smoke prevention are considered and integrated into these plans, this opportunity will be lost, and the post-war years will see the unnecessary creation of new sources of smoke as well as the equally unnecessary continuation of smoke emission from existing sources.

It is therefore imperative that every effort be made, and made now, to ensure that full cognisance of the problem is made by Government Departments and Committees, and others, dealing with subjects into which enter either smoke prevention or the consequences of smoke.

The National Smoke Abatement Society has already made a series of proposals that have been published in the form of a printed memorandum which has been submitted to the Departments concerned. Proposals relating to domestic smoke prevention have been amplified in a further memorandum submitted to the Design of Dwellings Sub-Committee of the Ministry of Health. It is not necessary here to recapitulate in full these proposals or the arguments leading to them, but for convenience the more important points may be summarised :

(1) With respect to fuel-burning

appliances in all premises other than domestic : All new plant and appliances and alterations should be required to receive the approval of a competent authority with regard to efficiency, suitability, and smokelessness before they are installed. In many industrial plants this will not end the possibility of smoke, and further control may be required, but in what are termed “commercial premises” (e.g., offices, hotels, etc.) automatically smokeless installations can be readily ensured and should be made obligatory.

(2) With respect to domestic smoke : given requisite attention in good time for planning the increased production of the smokeless fuels, mediums and appliances required, all post-war housing can be made entirely smokeless. It is maintained that this reform, considerable though it is, is feasible and will in more ways than one be advantageous to the national well-being. In the event, however, of it not being completely attained from the beginning, then it may be urged that not more than one open fire should be permitted in each house and that this should be of the most modern and efficient type available and capable of burning any form of smokeless fuel without structural alteration. Apart from direct methods for smoke prevention much-needed improvements in the standards of domestic heating can be attained and will lead to a greater efficiency of fuel utilisation.

(3) Central or other suitable areas in all large towns should be scheduled to be rebuilt only with smokeless methods,

so that at an appropriate date they may be declared to be smokeless zones. These smokeless zones will eventually include the whole of each town. This further stage is embodied in the Society's "Ten Year Plan."

(4) Since the Memorandum was printed a further proposal of importance has been made and it may be convenient to quote this in full :

"The establishment of local or regional authorities for the approval of installations will require some form of national co-ordination to secure uniformity of practice and the dissemination of new information, particularly on technical advances. The control organisation required could appropriately concern itself with the task of surveying the sources of pollution with a view to establishing the responsibility of each type of source, both with regard to the quantity and nature of emission. Such work, designed entirely from the preventive standpoint, could be associated with the promotion or co-ordination of researches designed to prevent such pollution or with ensuring that the use of new methods and techniques resulting from research is made known to and encouraged by the authorities dealing with new installations and alterations."

The Society's further proposals, termed the "Ten Year Plan" do not directly concern the particular subject of this conference, for they relate to a time following the immediate post-war period of new building. Until this first period is concluded, fuels and appliances will not be available for a large-scale change-over of existing premises to smokeless conditions. The Ten Year Plan has, however, one important bearing upon the problems of immediate reconstruction. It demonstrates that the measures to ensure smokelessness in new premises are not to be regarded in isolation from what now exists, and that they are in fact the first stage of the more extensive plan that will have for its purpose the complete abolition of smoke from all our towns. Without such understanding it might, to some, appear to be of little value whether the new premises (which will usually be among or adjacent to existing premises) are smoke-

less or not. The Ten Year Plan is the logical and necessary sequel to the proposals for the first stages of reconstruction, and if such a plan can be shown to be practicable and desirable then there is all the more reason for achieving the preliminary stages.

The Society's proposals have had some publicity and have received resolutions of support from over eighty Local Authorities, including most of the larger cities and boroughs. They are nevertheless, in some respects, still in the embryo stage and need further examination and amplification. In particular the practical measures required to translate them into actuality need to be propounded in the form in which we can reasonably expect them to be incorporated in legislation.

This conference has therefore been called to initiate the further discussion required and to learn directly the views and suggestions of members of the Society and of the representatives of the Local Authorities who will be directly concerned with the practical application of the new measures.

Although the Executive Committee does not wish to restrict the scope of the discussion it is hoped that this may be directed to the immediate subject of the conference, and suggests that in particular attention might be given to the following points :

- (1) The nature of the regulations required for the operation of the proposals relating to the pre-installation approval of new plant and appliances.
- (2) The form of organisation required for this purpose, e.g., local or regional; qualifications of staff, etc. The form of the national co-ordinating body also recommended.
- (3) The legislative questions affecting the establishment of smokeless zones.
- (4) The problems of application of smokeless zones in specific instances.
- (5) The domestic problem: the attainment of complete smokelessness in post-war housing, and, in the event of failure to secure this, the secondary policy to be advocated.

- (6) Ways and means for developing and advancing the agreed proposals of the Society.

Some References

Memorandum on Smoke Prevention in Relation to Initial Post-War Reconstruction (*N.S.A.S.*, 1942).

Memorandum on Design and Equipment in Post-War Housing, in Relation to Smoke Prevention (*Smokeless Air*, Autumn, 1942),

Plan for Clean Air (*N.S.A.S.*, 1943).

The Provision of Smokeless Fuels, by Dr. G. E. Foxwell (*Smokeless Air*, Summer, 1942, and *Journal Inst. Fuel*, XVI, No. 87, Dec., 1942).

The Cost of Abolishing Smoke, by J. Patrick (*Smokeless Air*, Winter-Spring, 1943).

Smokeless Zones (*Proc. Leeds Conference*, *N.S.A.S.*, 1937, *Smokeless Air*, Summer, 1941, Autumn, 1943, etc.)

In view of the shortness of time before the lunch adjournment it was agreed to consider a resolution proposed by **Mr. JAMES LAW** (Sheffield, Rotherham, and District Smoke Abatement Committee) on the question of the present situation with respect to smoke emission. Mr. Law said:

You have heard about the ostrich who "buried his head in the sand on the approach of his enemies" and you have probably heard about the country that tried to hide from its enemies by covering its cities and towns with smoke. Whether this served any useful purpose the historians may be able to tell us in a couple of generations, but the cost in fuel must have been tremendous and will never be assessed.

Later came a fuel shortage and appeals were made for greater fuel production and economy in use. The natural sequence to this should have been the rescinding of the order, but it was not thought necessary or expedient to do so. It was also thought that the quickest and most practical method of economising in fuel would have been to insist that chimneys should not emit excessive smoke, but in this there was again disillusion. Bulletins were issued on the construction of steam flow meters, the insulation of pipes and the systematic

measurement of coal, but practically nothing on heat losses occasioned in the boiler flues and flue gases where the greatest waste can occur.

Discussions have taken place on Post-War Reconstruction and Planning, but when a dispassionate review is made of the situation it would appear to be futile to make plans until the present obscure situation is cleared up.

Is there to be any control to prevent the present waste of fuel? Are there to be any Enforcement Officers to insist that reasonable combustion conditions are in operation?

I have been a Combustion Engineer for over 30 years both ashore and at sea, but I have never seen conditions worse than those in the industrial cities and towns of the north during the past two years and I think other delegates from the north will agree with me. Our statistics show an increased pollution figure of over 50 per cent. in the industrial area, but observations show that excessive smoke emission is approximately seven times as great as in 1939, the deposit being carried by the wind for many miles into the surrounding districts.

I am going to put a resolution to this Conference, which I hope you will all support, as follows:—

"That this Conference of the National Smoke Abatement Society representing 130 local authorities views with grave concern the increased atmospheric pollution, particularly in the industrial towns of the north and requests the Minister of Fuel and Power to take such action as he thinks necessary to obviate this waste of fuel as quickly as possible."

A number of speakers supported Mr. Law, and representatives from the South and Midlands affirmed that the conditions he had described were not peculiar to the North of England. **Councillor J. COOT** (Ebbw Vale) spoke on the question of a serious dust and grit nuisance experienced in his district and described some of the effects of this upon the homes and people suffering from it.

It was agreed that consideration of the resolution should be made at the time of, and in relation to, other resolutions that would be considered at the end of the afternoon session.

The Conference then adjourned.

Afternoon Session

Chairman : Mr. Charles Gandy

The Chairman read an apology for the unavoidable absence, because of Parliamentary duties, of Mr. E. H. Keeling, M.C., M.P., who was to have presided at that session. He then called upon the first speaker in the discussion.

Miss ELIZABETH DENBY said she was appalled to see how smoke was drenching the countryside more and more each year. She did not think the Executive's statement went far enough, and suggested the Society's name might well be Smoke Abolition Society and not Smoke Abatement Society. The Statement did not hold out any immediate prospects of dealing with the smoke nuisance. Four and a quarter million houses were built before the war, and only 100 of them were completely smokeless. Local Authorities should make the abolition of smoke one of their prime duties. Women would endorse the statement that homes should be smokeless, but would always want an open fire. Attention should be turned to the manufacturers of heating equipment, who should be encouraged to produce attractive equipment for the burning of smokeless fuel in open grate.

Miss CAROLINE HASLETT (Electrical Association for Women) stressed the importance of the opinion of housewives. More women's organisations than ever had recently sent in suggestions on housing and similar problems. A Standing Joint Committee of Women's Organisations had been formed to study civic and national problems. The co-operation of these organisations should be enlisted in the fight for smoke abatement.

In wartime, continued Miss Haslett, everybody was more concerned than ever about housekeeping, and one was doubly conscious of anything that accentuated these difficulties. We had less time, less soap, and no hot water to waste if we were economising in fuel. It was therefore extremely aggravating when one had kept one's own house clean to have to battle with the dust and smoke from someone else's

chimney. It should be as great an offence to make other people's houses dirty as it was to deface their property.

If something was not done about it the beautiful new buildings of the post-war cities would become begrimed and as bad as their sooty predecessors. We were willing to put up with drabness in wartime, but were all longing for cleanliness and colour and freshness in the post-war world. In post-war building flat roofs and sun gardens were to be expected. But what use would they be if they were covered with dust and smuts? We were expecting more open spaces, more gardens and green belts in cities, but Miss Haslett believed that although the nitrogen was there the pores of the poor plants became so clogged with soot that they could not absorb it.

Dr. R. LESSING said that what the Society was really after was local or regional clean air, and he would prefer to have a "Clean Air Society." The pollution of the air was caused not only by the visible smoke, but also by the acid gases which were generated by the combustion of such fuel as raw coal, and the damage was mainly done by the invisible sulphur gases. The emission of visible smoke had diminished in the last thirty years, but it had been replaced by the emission of grit and dust by factory installations.

We were in a position to-day to say that the technical problems had been solved, and this had been done on a large scale at the power stations at Battersea and Fulham. Forty million tons of coal were being burned a year in the home and small industrial premises, and the replacement of this by a smokeless fuel was a formidable task and could only be done by the technicians and by the sympathetic support of the Government or authority who had to countenance the change.

Mr. V. W. DALE (British Electrical Development Association) said :

Unless I am extremely careful there is a risk of merely repeating many of the

things that have been said already, here and elsewhere, by more able contributors: there is little or nothing new that can be said at this time about the evil effects of smoke and polluted atmosphere both on persons and property and perhaps little purpose can be served at the present time in staging another "indignation meeting" demanding some speeding up of smoke reform by Authority.

In the United States the miners seem to be lending a hand in the abatement of smoke: over here fuel economy and all the action that is being taken to improve combustion and efficiency—particularly in industry—is no doubt making its influence felt on the smoke nuisance.

I am sure nothing I say will be construed as propaganda for anything but smoke abatement although you will expect me to say a few words about the industry with which I am associated.

Looking ahead into the immediate post-war years I suppose there are few things which can contribute more to the Society's objects than the spreading of the use of electricity and gas and the further development of improved coal burning grates and furnaces of all classes.

As regards Electricity: since the work of this Society commenced many years ago two or three notable events have occurred which contribute notably to its objects and which reflect further contributions after the war.

First: the per capita consumption of electricity in this country ten years before the present war was ten times greater than it was ten years before the last war. But, at the outbreak of this war the per capita figure was actually forty times greater than it was at the beginning of the century. The extent to which this normal development of a commodity which, when used as a fuel, is smokeless both in distribution and at the point of its application and use—needs no comment.

Second: technical improvements have brought about a great reduction in the amount of coal needed for each unit generated with the result that whereas twenty years ago one ton of coal produced eight hundred units, to-day the most efficient generating stations produce three times that number of units.

Third: Concentration of electrical generation in a lesser number of highly efficient selected stations is, in itself, again another vital contribution to the reduction of the smoke evil.

These thoughts at once link up with post-war considerations. If we visualise development over the last twenty years and note particularly the nature of the curve in the last decade I think it will be readily seen that the destiny of the Electrical industry and the gradual and ultimate achievement of the objects of the Smoke Abatement Society run very much in parallel.

But there are some disquieting symptoms.

"Smoke is money"—if that is true, or if at least true by influence, we all know that as soon as hostilities cease Britain will simply be compelled to seek export markets—old and new—and she must again be at least *one* of the principal workshops of the post-war world.

In order to make as sure as possible that there is no calamitous reaction on smoke abatement it appears to me that the Society should direct our attention urgently to three things—Press—Politics—Planning.

(1) *Press*. We need a much better public knowledge of the dreadful ravages of smoke—I need not recite them. At this Conference we are preaching to the converted. We should, in my opinion, start right away to persuade the Press that smoke abatement is not a novelty or a fad—but that it is continuous news.

(2) *Politics*. We should watch out for every opportunity to promote legislation which will tend progressively to reduce to an absolute minimum, emissions of smoke in densely populated areas, particularly from the domestic chimney.

(3) *Planning*. We must see to it that there is no cheese-paring in the provision of smoke reducing appliances and, equally important, in the use of heat insulation materials in the ten-year four-million-houses Government plan.

I cannot tell you in any great detail what measures are being taken by the electrical industry, mainly for the reason that during the last three years or so we, in common with our contemporaries in the fuel industries, have been making an effective contribution to smoke abatement by appealing to the

consumer day in and day out to *use less fuel*. I am glad to say that there was a good deal of evidence last winter to show that the consumer responded—we are not quite so sure what he is doing about it this year.

Apart from that our manufacturers, almost without any practical exception, have been engaged on high priority war work and have had little or no time for post-war problems. But I can say that plans are being formulated for the production of electrical appliances the use of which must have an over-all effect of contributing to a solution of the menace which is the single concern of this conference.

I would like to mention one other thing: we have recently developed and have ready to demonstrate to the Minister of War Transport a National Standard Electric Vehicle. Mr. Noel Baker has prophesied that in five years after the war the number of motor vehicles on the road will be quadrupled, the meaning of that statement in regard to atmospheric pollution is pretty obvious.

My Association, the Electric Vehicle Association, believes that in the "Electric" we have an effective answer to this side of your problem.

The electric vehicle attacks the worse offender on the road because of its special suitability in urban areas where traffic density and slow movement increases the peril. May we also hope—indeed the last few days have produced some reason to hope—that there will be a rapid speeding up of *railway electrification* in the immediate post-war years.

I hope also, we shall not overlook the need to keep the insides of our homes free from dirt, and dust, and smoke.

Where do we go from here: I don't suppose the Smoke Abatement Society is wondering what to do at the next immediate stage, but I would like to suggest that it might well devote itself first to these three things:—

(1) To lend its support wherever it can to secure better heat insulation in new housing design.

(2) To amplify that aspect of abating a nuisance which can express itself in saving, or reducing waste—whether it be fuel, spoilation of property or menaces to health. In this way the Society will be keeping a place for itself in a post-war world where waste

will perhaps be a sin.

(3) To widen the scope of the Society's work from abating smoke to abating dirt and promoting air purification and air conditioning generally.

I agree that some of these activities may tend to overlap with similar activities by other bodies. Some day perhaps all these things will be federated and the work divided out—but for the moment, perhaps they are more healthy for being independent and we are gaining more than we are losing through duplication.

In conclusion, there comes to my mind two lines from the sonnet "On Westminster Bridge." It runs, I think: "Ships, towers, domes, temples and theatres lie
all bright and glittering in the
smokeless air."

Not only Westminster—we want to see Wapping and Wolverhampton and Wigan . . . "all bright and glittering in the smokeless air" . . . I am sure I can promise this conference, Mr. Chairman, that the electrical industry's plans for, and contribution to, post-war reconstruction are very definitely and closely allied to that objective.

Dr. J. JOHNSTONE JERVIS
(M.O.H., Leeds) said:

The truth is that smoke connotes waste, waste of fuel, waste of money, waste of all that is beautiful in architecture and in the countryside around our cities, waste of human health and life. That being so our duty is plain and it is to get rid of smoke. We have tried compromises and they have failed. For the last twenty years of my public life I have been struggling with the problem, suggesting this remedy and that and all to no avail.

As regards industrial smoke there has certainly been some improvement but in domestic smoke progress has been lamentably slow and there is very little to show for all our efforts.

How long must we continue trifling with the problem? Has the time not come when in the interest of national economy and public health we must get down to the root of the trouble, which is the burning of raw coal? Viewed from whatever angle, to burn coal in its raw state is no longer justifiable seeing that there are available so many satisfactory substitutes which give the same result with none of the concomitant

evils. The only way to achieve this purpose, in my view, is to prohibit the use of raw coal altogether except where it forms part of an industrial process and there is no satisfactory alternative.

That, it may be thought is a counsel of perfection and too utopian. Nevertheless, I make the suggestion fearlessly in the full conviction that it is the only way to reach the goal we are aiming at which is a smokeless atmosphere.

The time for palliatives has gone. We must now determine on a radical cure, and I seriously suggest to this body that its policy in future should be the abolition of smoke and not merely its abatement.

Mr. J. W. BEAUMONT (Chairman, West Riding of Yorkshire Regional Smoke Abatement Committee) said :

Industrial premises : Since the passing of the Public Health (Smoke Abatement) Act of 1926, the provisions of which are now incorporated in the Public Health Act, 1936, I think it will be agreed that there has been a steady, although slow, improvement in existing fuel burning appliances. In addition, to this there has been an increasing use of electricity and gas in the production of power. We are, I think, justified in thinking that these improvements and conversions will continue in the post-war period. Our main consideration, therefore, should be given to the subject of the installation of new plant and appliances in the first place, and secondly, any action we can take to deal with obsolete plant which cannot reasonably be adapted to consume its own smoke.

What competent authority can be set up to deal with those matters? Should they be local or regional? What form of national co-ordination can be devised to secure uniformity of practice and dissemination of information on technical discoveries and advances?

In recent years we have heard much of the necessity for a National Fuel Policy to conserve our natural resources and—more important still—to obtain the maximum benefit from these. This is obviously a matter for the Ministry of Fuel and Power. This body should provide the necessary co-ordination and disseminate information of scientific and technical importance to any regional authorities that may

be set up and local authorities. It is questionable whether there would be any need for a regional authority to deal with the matters mentioned, provided local authorities availed themselves of their opportunity to set up a competent authority.

In this connection the action taken by Manchester is worthy of note and commendation. There has, I understand, recently been formed a Committee to be known as the Smoke Abatement and District Heating Technical Committee. Included in its members are the City Surveyor, City Architect, Housing Director, Gas and Electrical Engineers, Chief Sanitary Inspector and representatives of the Heating and Ventilating Engineers. It is difficult to imagine a more competent authority to approve the installation of new plant and pass judgment on the obsolete.

Commercial premises : This term includes all offices, warehouses, hotels and other non-industrial premises, excluding dwelling houses. Here there are no particular difficulties since there are to hand the means for making them all smokeless in operation. For a commencement, however, and as a prelude to any general compulsory measures which may be found necessary, the establishment of smokeless zones is a procedure which has much to recommend it. It is the "bridgehead," so to speak, from which the area of smokelessness can be extended until it comprises the whole. The power of example is great, and here again it is obvious that the Government should take the lead by ensuring that all premises over which it has jurisdiction, should be rendered smokeless. With such an example—or even without it—local authorities should take similar action which should precede any request for additional power to establish smokeless zones.

Under Section 47 of the Public Health Act, 1936, a local authority may pay part of the cost of conversion of closets to water closets. If this was considered to be necessary, why should not a grant be paid to those who, by carrying out the necessary work, cease to pollute the atmosphere by the emission of smoke? The local authority and the community at large would derive great benefit thereby.

Domestic premises : The provision of sufficient houses to replace those demolished as the result of enemy action, to meet the deficiency which has accumulated during the war years, owing to the cessation of house building, and to complete slum clearance and overcrowding schemes, will provide the greatest problem of post-war building.

It is a well-known fact that domestic smoke forms no small part of the general pollution of the atmosphere. Indeed, many people are of opinion that it forms the greater part. In any case it is obvious that, before complete smokelessness can be achieved, the problem of domestic smoke has to be dealt with.

Whatever opinions one may hold as to the wisdom of attempting by legislation to force a reluctant majority of householders to cease burning bituminous coal in an ordinary fire grate, it will, I think, be agreed that in the case of new house construction of the magnitude required, it would be utter folly if we did not take advantage of the opportunity to see that as far as possible such houses should be smokeless. To this end all possible steps should be taken to substantially reduce the cost to the user of gas and electricity, and special grates should be provided to burn solid smokeless fuel where such are necessary. The fullest advantage should also be taken of central heating where such can be advantageously applied, and the possibilities of district heating should be fully explored.

As rehousing measures will be very largely the concern of local authorities, there should be set up an adequate committee to deal with the matter, on the lines of the Manchester committee, whose duty would be to ensure that in all local reconstruction work the question of smokelessness would receive due consideration.

Where special grates have been provided to burn solid smokeless fuel, it should be made an offence if such are used for the burning of bituminous coal. At a later stage, when we are assured that there are adequate supplies of smokeless fuel available for all our needs, any legislative steps necessary to ensure its proper use could then be taken.

Propaganda : Despite the fact that the

evils of atmospheric pollution by smoke is daily before the eyes of our people—especially those who live in industrial and urban communities—it is unfortunately true that in the main they do not recognise these evils or realise that they are preventable. Definite steps, therefore, should be taken to provide a wider instruction of the public in general and schoolchildren in particular, in methods of healthy living with reference to atmospheric pollution.

Mr. F. J. REDSTONE (Chief Sanitary Inspector, City and County of Bristol) said :

I have listened with great interest to the paper we have had this morning, and to the other speakers in the discussion this afternoon, and one thing particularly pleases me, and it is that the National Smoke Abatement Society is now widely enlisting the help of practical people in formulating plans for the future. Old-fashioned, filthy and wasteful methods of heat production, whether it be for industrial or domestic purposes, must be swept away. Science has provided the methods whereby this can be done, and we are now co-opting the sympathies of people who know how to do it.

At the present time the law recognises that the methods in general use cannot be worked without nuisance, and it was encouraging to hear the City Engineer for Bristol state at a recent re-planning conference that the problem is a serious one, and that more attention should be given to it.

There is one important point in connection with new and smokeless methods that I would like to emphasise. It is not a bit of use appealing to the housewife to use smokeless fuels that cost more money than coal, whatever our arguments the housewife places initial cost first, and for that reason I hope there will be adequate control regarding prices of new fuels or old fuels used under new methods.

To those of us that live in what people are pleased to term a reasonably clean town, I would say do not let us be satisfied with a reasonably clean town, but strive to establish a really clean town. I am quite sure that this Society is doing a great deal to attain that end.

Councillor Mrs. ALDERSON HORNE (Westminster) said :

I am an advocate for the retention of one open fire in every house. The open grate not only warms the air but ventilates the room, and psychologically it cheers and soothes nerves.

Smokeless coal should be used—the criticism of it is that it is costly, but this is generally owing to the fact that it is being wrongly treated. We should play fair and give it its chance, for it is the faulty stoking and the ill-adapted grate which make it burn away too fast and so become an extravagant luxury. Cannot a grate be put on the market with a solid bottom, thus giving less draught, and with vertical bars in front to ensure that ovoids does not roll through and out ?

In my little two-hundred-year old house in London I experimented with every make of smokeless fuel then on the market, and the most successful was burnt in the old grate into which I had fixed a solid bottom—I used 23 or 24 pounds, including the laying and lighting, in a day of fifteen hours, and with coal costing at that time 55s. a ton I calculated that my fire cost me 4s. 1d. a week. In that I had real warmth in my room, which measures 18 by 16 ft.

Mr. LESLIE HARDERN (Gas Light and Coke Company) said :

I propose to talk about the open fire as this appears to me to be the biggest single problem facing us.

I do not think it is generally realised, and many people have expressed surprise when I have told them, how many smokeless solid fuel open grates were being installed in houses and flats in Greater London just before the war. The number had risen in a few years to the surprising peak of 150,000 grates a year. Moreover, all these grates were being sold without any advertising or sales pressure—simply by personal recommendation. Bearing in mind that they were early models, and that very considerable progress has been made since 1939 in the design, draught-control and flue construction of these smokeless grates, one could imagine an intensive educational campaign after the war resulting in the installation of some 300,000 to 400,000 smokeless fuel grates a year. In other words, smokeless

fuel grates would be installed in all the homes in Greater London in some five to seven years.

Having painted this very attractive picture, I must now describe the seamy side. A very large number of these smokeless grates are being used to burn—not the smokeless fuels for which they were intended—but raw coal. In view of the great importance of this problem, I have recently been carrying out some investigations in London, as far as wartime conditions permit, to find out why people are using raw coal in these grates. The main reasons given are (1) liking for the flames of a coal fire, (2) fondness for poking and breaking the burning coal, (3) variations in the qualities of smokeless fuels, (4) need for more frequent stoking, (5) inadequate storage space for the extra bulk of smokeless fuel, (6) difficulties in obtaining deliveries as compared with coal, (7) the high price of smokeless fuel compared with raw coal.

Some of these are wartime difficulties. For instance, variations in smokeless fuel qualities unavoidably follow variations in the qualities of coal deliveries; many people have been registered with coal merchants who could not supply coke, and dual registration has only recently been permitted; official price regulations have resulted in greater increases in coke than in coal prices.

Two other difficulties can be overcome in post-war reconstruction. Adequate storage space for smokeless fuel can be made an essential of new houses and flats. The new smokeless fuel grates, with their greater control of speed of burning, reduce stoking periods.

The remaining difficulties—the longing for flames and poking, can only be overcome by continuous and persistent public education on the lines advocated by this Society.

I am confident that when the war is over the right equipment will be available—smokeless fuel grates of good design in coloured enamel, with precision-control of burning, simple ignition by gas instead of paper and wood, inexpensive to supply and instal.

The right equipment, however, is not sufficient. Unless we make sure that we get uniform qualities of smokeless fuels, prompt and regular deliveries, adequate storage space, and above all, prices which do not exceed the prices

of raw coal, we shall not solve the smoke problem of the domestic open fire.

Alderman J. J. MILTON, J.P. (Chairman, Bristol Health Committee) said :

Whilst Bristol is not a centre of heavy industry the Health Committee is alive to the smoke problem, and with the object of establishing a cleaner atmosphere in the area, the Bristol and District Regional Smoke Abatement Council had been formed. The work of this Committee has been seriously curtailed due to war conditions, but it was hoped that further meetings would soon be held with the object of continuing the good work already started.

A great deal had recently been heard about district heating, and at the present time Bristol was seriously considering such a scheme—I believe the first to be submitted in this country. The scheme before the citizens of Bristol was a “heat distributive scheme” which would cover an area of approximately 345 acres in the centre of the city. It was costly, with an estimated expenditure of over a million pounds and at the present time the Bristol Corporation was in no way committed to it; but taking the long view there was no doubt it had great remunerative possibilities apart from its amenity value. The scheme was much in line with the Society’s suggestion of creating a smokeless zone.

Mr. EDWARD ROBINSON (Sanitary Inspector, Houghton-le-Spring) said that the Society should urge the Government to take action regarding the nuisance arising from colliery spoil heaps, having regard to the fact the heaps were being increased in height by the new process of depositing refuse. As the majority of houses in a mining area were built within easy reach of the pitheads, it was quite easily understood how these high unsightly heaps were depleting light and breathing space of the people living in such houses. As smoke and fumes nuisances from the heaps affected the public health and well-being of the local inhabitants, the Government should consider post-war schemes to abolish this nuisance for all time.

Councillor the Rev. R. BURGESS (Beckenham) urged that the Society, in extending its propaganda, should make more use of the parsons. Parcels of literature should be sent to them and they should be asked, not to give lectures on the subject, but to introduce it into their sermons. There were plenty of texts in the Bible on health and cleanliness. Another body of people who would be sympathetic towards the Society’s aims would be the allotment holders, whose labours were often spoiled by the smoke nuisance. He suggested that their national association be approached.

Dr. G. E. FOXWELL said :

It appears from the discussion that many members are not acquainted with the work that is being done by the Fuel Efficiency Committee of the Ministry of Fuel and Power. As this work is of great importance in the abatement of industrial smoke it is well that something of what is being done should be put on record. The Fuel Efficiency Committee was set up some two years ago when the need for saving coal became apparent. The Main Committee is composed of men of wide experience in all the fuel industries of the country. It has several sub-committees, one of which for example deals with education, and another with technical matters. The Education Committee, for example, has been running a great educational programme in fuel technology for works engineers, stokers and others. Already some ten thousand people have attended these courses. The Technical Committee has issued some 30 bulletins to assist in the better utilisation of fuel. The Trade Association Sub-Committee has enlisted the co-operation of all the important fuel using industries in the country, most of whom have set up their own fuel efficiency committees to deal with their own problems. I would point out that the great improvement which is now being made in the technical use of fuel and the great increase of knowledge on the part of those who are responsible for works boilers and furnaces must change the situation very vitally. If fuel is burnt efficiently and if appliances are maintained as they should be, the production of black smoke in industry will auto-

matically cease. I am sure that the Ministry of Fuel and Power will be very responsive to any suggestions that can be made by the Society to this end.

The general problem of smoke abolition has three facts : (1) Political, in the acceptance by Parliament and by local authorities of the need for legislation to further the cleansing of the air ; (2) The acceptance of the programme of the Society by the nation in general ; this is primarily a propaganda and educational programme, and, of course, if it is successful the political programme is made easier ; (3) Technical considerations to which (1) and (2) must be subservient because it is no use advocating policies which cannot be put into effect for technical reasons.

I should like to make the suggestion that the Society should set up three distinct panels. A political panel, which would of course include all Members of Parliament who are members of the Society, a publicity and educational panel (the suggestion made by the Reverend R. Burges that the Church might be persuaded to take a hand in the work of the Society would come within the purview of this Committee), and a Technical Committee which would consider the technical aspects of smoke abolition in all its many angles. It has often seemed to me that in view of the widely diffused interests of members of the Society some crystallisation of effort and some authoritative body to which important questions can be remitted, is desirable.

It is on the technical aspect of the subject that I wish to speak. Complete abolition of even a light smoke haze is not always possible in an industry if raw coal is to be burnt efficiently. When chimneys are sufficiently high this may not be a matter of any consequence but observation has shown me how a town of some size can blot itself out to an observer on a neighbouring hill by the production of light smoke haze and without any single chimney producing black smoke. In the light of this observation I would urge that the Society must stand for *complete* abolition of *domestic* smoke. This means that it is not possible to allow one raw coal fire per house (few houses burn more than one fire at a time, anyway) and it means that it cannot be permissible to permit grates

which only reduce the present amount of smoke. These are palliatives and not a solution. It is necessary if the ultra-violet rays are not to be cut off to insist absolutely on the use of smokeless fuels for domestic purposes.

One of our principal problems to-day is coal conservation. The present position of our coal supplies is such that we are already facing the exhaustion of our best seams and that within the lifetime of many of those present we shall be driven to deeper or more expensive or inferior seams and we shall be in a much worse position in this respect than either Germany or America. I need not remind you what this will mean to our industrial position. The problem of smoke abolition must therefore be viewed against the wider problem of coal conservation.

From the angle of coal conservation it is indefensible to use electricity for domestic heating, unless some means, such as district heating, can be found for raising the thermal efficiency of electrical generation to about 50-60 per cent.

Including the various transformer and distribution losses, 1 ton of coal produces some 1,400 units at the consumer's appliances, and even if this is used with an efficiency of 100 per cent. the efficiency is only 17 per cent. or 48 therms per ton.

Compare this with modern carbonisation practice (Table I).

The high efficiency makes for cheaper fuel, as well as smokeless fuel. The first step, therefore, is to popularise the use of the products of carbonisation for domestic heating purposes. All is not well in that direction because in the North there is difficulty in many regions in selling coke for domestic purposes, largely because the domestic hot water boiler, coke-fired, has not been popularised as it has in the South.

There has been something lacking in the approach, and the difference between the North and the South indicates that preaching smoke abolition is not enough ; we must decide in what way we are going to abolish smoke and prove to the people that the means that can be provided for the purpose are satisfactory, clean and cause them no inconvenience.

Much good could be done by the propaganda of the Educational Com-

TABLE I (based on coal of 300 therms/ton)

	<i>Therms made</i>	<i>Fuel used in</i>	<i>Effi. %</i>	<i>Therms used</i>	<i>Fuel used in</i>	<i>Effi. %</i>	<i>Therms used</i>
Gas ...	75	Gas fire	50	37.5	Gas fire	50	37.5
Coke ...	145	Convection open fire	65	94.3	Closed hot water boiler	80	116
Tar ...	20	Steam boiler	70	14	Steam boiler	70	14
Total ...	240	...	...	145.8	...	...	167.5
Efficiency ...	80%	...	...	48.6%	...	...	55.7%

mittee which I have proposed. In the South we have already discovered that a domestic coke boiler will heat a kitchen and maintain constant hot water day and night and that a gas cooker is the ideal method of cooking. A combination of these two will virtually solve the domestic smoke problem for most houses because it is also possible to open the front of the domestic coke boiler in order to make it into an open fire. In the North, however, this solution does not appear to have been brought adequately before people with the result that it is much more difficult to sell coke for domestic consumption.

I have analysed elsewhere the quantities of smokeless fuel required and how this fuel is to be produced. (See *Smokeless Air*, Summer, 1942, and *Journal Inst. Fuel*, XVI, No. 87, Dec., 1942). The general effect is that if we relied upon new construction to produce the necessary coke and gas we should have to multiply the gas industry $1\frac{1}{2}$ times. This of course would cause enormous capital expense and would take some time, but no industry objects to expansion if it can sell its products.

By taking advantage of the renewals of coking and gas plants that must follow the war we can find about half the heat without increasing our existing capacity, and with very considerable additional saving in coal. The other half would come from new construction. This must take some time, but there should be no difficulty in providing what is necessary, *provided that we are told before the reconstruction period starts that there will be a market for the smokeless fuel if we produce it.*

But the problem will not be quite as simple as that. People who are to use

smokeless fuels must be given fuels that are fully satisfactory. Part of the difficulty is practice; people must learn how to use fuels to which they are not accustomed. It is very difficult to educate people who do not really care whether they learn or not.

The technical men must therefore get busy to make things easy for the user :

- (a) Better appliances for burning coke must be developed. I have some reason for saying that immense advances have taken place in the design of many appliances, and that these appliances will be ready when the works have had time to change from war to peace production.
- (b) Improvements in the quality of coke must be made. The technical basis for this is known, but has not been put into practice as yet except in a few places.
- (c) The same need for improving gas appliances does not exist; great improvement was made in the years between the two wars.
- (d) A really difficult matter is the balancing of the demand for coke and gas. Coke can be stored; gas can only be stored for a few hours. Thus unless coal is to be wasted, we must not make gas that cannot be used within 24 hours; and we must not make coke that cannot be used within a year or so. The essential difficulty of this problem is to replace a fuel that can be stored indefinitely by two fuels produced simultaneously, one of which cannot be stored.
- (e) One solution of this problem is the total gasification process now being developed by the gas

industry; this would allow gas to be made without making coke, but not vice versa.

The general conclusion is that whilst technical arguments point to carbonisation as the most satisfactory way to provide the necessary smokeless fuel, the problem of how to do it still requires a good deal of thought, and possibly some considerable changes in technique in carbonisation and appliance design.

Finally, it has been stated by others who have taken part in this debate that the cost of smokeless fuel must not be markedly greater than the cost of the raw coal it displaces. One answer to this is that smokeless fuels (as shown in Table 1) can be used with a much higher efficiency than raw coal and a higher fuel cost may be compatible with a lower total cost. But the most satisfactory answer is the demonstration by the Gas Light and Coke Co. at Kensal House that the whole fuel requirements of a domestic household can be met by gas and coke at no higher cost than by raw coal.

Councillor Mrs. A. A. BARNES (West Ham) said:

One speaker considers that Smoke Abatement should be taken as a subject in schools, and I suggest that the Board of Education might be asked to include it in the curriculum of Senior Schools and Technical Colleges. Technical education is to play a big part in the future of our schools, so in the engineering shops and building schools part of the training could be the right type of machinery to be used for the prevention of smoke.

Prior to the outbreak of war we had in our Senior Schools in West Ham flats which were run by girls taking Domestic Science. Gas and electricity were installed for cooking purposes, and there again the pupils could be taught the right kind of fuel to be used for smoke prevention, stressing it as very largely a matter of health education also. In many of the homes of these girls who took the course the mothers have found that some of their old ideas have been questioned, and that is why I feel these things could be of use in propaganda for the Society.

Mr. JOHN CHARRINGTON explained that he was called to be present both in his individual capacity as a Coal Distributor and as Vice-President of the Coal Utilisation Joint Council, and he wanted to make it plain that the coal trade were seriously interested in the question of smoke abatement.

On the industrial side he referred to the proposal of the C.U.J.C. to establish an Institute of Coal Utilisation Technologists, the function of which would be to supervise the education and training of experts in combustion. It was believed that the Institute was needed both on behalf of consumers who wanted qualified men to supervise their boilerhouse, and by coal distributors who would increasingly need trained representatives to discuss the coal requirements of their various customers. Smoke, after all, represented waste, and Mr. Charrington said that in his opinion waste in a boilerhouse would be watched with increasing care in future.

Turning to the domestic side, he gave as evidence of the interest which coal distributors are now taking in the better use of coal, the fact that they had recently subscribed £20,000 as part of a much larger fund which had been raised by colliery owners, appliance manufacturers and coal distributors for expenditure upon research into better coal burning appliances. This work had already borne excellent fruit, and a domestic fireplace would soon be on the market which would not only give the housewife infinitely less trouble, but which had already shown that it could reduce a normal smoke emission of $2\frac{1}{2}$ per cent. to something under 1 per cent. and he claimed this as a considerable advance in the problem of smoke abatement.

Mr. Charrington took exception to a remark which had been made earlier in the Conference, claiming that the producers and distributors of solid smokeless fuel had availed themselves of the publicity which the Smoke Abatement Society had given to these fuels to steadily increase their price. This remark was neither true nor fair, as it had to be borne in mind that processed fuels such as high and low temperature cokes cost money to produce, but that the prices at which

they were sold were strictly economical and reasonable.

Mr. Charrington regretted the tendency in the report of the Society to compel people to do this and that, as in his view the people of this country were much more inclined to be led than to be driven. Further, he thought that one open fire in a house was insufficient, and that the Ministry of Health had recommended that there should be at least one bedroom with and open fire in addition to the one in the sitting-room; moreover it seemed unreasonable to stipulate that nothing but solid smokeless fuels should be burnt in these open fires, for it was at least questionable whether a sufficient supply was available.

Mr. Charrington urged a policy of patience, particularly in view of the wonderful results which the Society had already achieved, and reminded his audience that what the people of this country really wanted was an open fire burning bituminous coal, always provided that bituminous coal could be burnt with little or no offence to one's neighbours.

Mr. A. E. MARGOLIS said:

Ever since I have worked in the field of district heating, and especially since I have had the privilege of living in this country, I have stressed the great importance of public heat supply from the standpoint of smoke abatement. It was a great satisfaction to me that district heating was included in your recommendations to the Ministry of Works and Planning, and Ministry of Health. Having now the privilege to speak at this meeting I shall try to show you that district heating is the best method of smoke abatement, in fact of smoke abolition.

The extent of air pollution naturally depends upon the quantity and the quality of the flue gases and the method of their discharge. The quantity of flue gases, when not diluted by excessive air, is in direct proportion to the weight of burnt coal. For the generation of the same heat demand the quantities of burnt coal are in reverse proportion to the thermal efficiencies. Taking, for the sake of simple comparison, thermal efficiencies in round figures, of 20 per cent. for coal fires, 50 per cent. for central heating boilers and 80 per cent. for a district heating boiler plant, the

quantities of flue gases for coal fires, central heating boilers and a district heating boiler plant are in the proportion of 10 : 4 : 2.5.

The quality of the flue gases, from the standpoint of air pollution, cannot be expressed in a simple proportion but for coal fires it is at least relatively as bad as for the quantities of flue gases.

Furthermore, the air pollution effect of coal fires is greatly increased by the discharge of the flue gases at a low level and in very small quantities which are quickly cooled down. It can often be observed that the smoky air is falling down into the streets. The heating effect of the houses causes at the walls an up-stream of the warmed air, and as a result a down-stream of the cooler air in the middle of the street. The force of this circulating effect being greater than the lifting force of the cooled flue gases causes the smoky air to fill the streets. In contrast, the flue gases of a large boiler plant rise to a considerable height before they are cooled down and, if the area of a town is not very large, are carried away and dispersed by the natural ventilating effect of the wind. Furthermore, the flue gases of large stations can be cleaned by electrostatic precipitation or other methods.

Finally, by co-ordination of heat and electric power generation, it would in the future be possible to generate the demand for heat and electric power with the same fuel consumption which is at present required merely for electric power generation. In other words, the total quantity of fuel which is at present used for space heating and hot water supply would be saved and the corresponding quantity of flue gases eliminated.

On the other hand the burning of smokeless solid fuel will eliminate only the visible smoke but it will not eliminate the pollution of air by flue gases. Moreover, the burning of smokeless solid fuel, perhaps with the exception of anthracite, is also accompanied by emission of grit as can be observed in certain town areas on the Continent, which are provided almost exclusively with central heating plants burning coke, by the blackening of the snow a day or two after it has fallen.

From the standpoint of district heating, heating by coal fires is a

waste of fuel, expensive, and always a nuisance to the neighbour. Coal fires, therefore, should only be used occasionally but all buildings of a town should be supplied with ample and cheap heat from mains in the streets like water, gas, and electric power.

It is often said that in this country, with its mild climate, there is no need for district heating. This is not so, firstly, because the ever increasing number of central heating plants shows the need for centralised heat supply and, secondly, the decisive factor is the quantity of fuel which is used for domestic purposes. Owing to the longer duration of the heating season, the greater demand for hot water and ventilation, and of course to the poor efficiency of coal fires, the annual consumption of fuel per head of population for heat supply is, in this country, approximately 50 per cent. higher than on the Continent. By the general introduction of district heating it would, in the future, be possible to save in towns and cities more than half of the total coal which is at present burnt for space heating, hot water supply and electric power generation.

It should be noted that the saving in coal was the main argument for the introduction of district heating in Russia. In the Spring number of *Smokeless Air* of last year I gave a short outline of the developments of district heating in Russia. In spite of great technical difficulties which are frankly admitted in Russian publications, and shortage of experienced labour, Russia is now leading in the development of district heating and the new Power Stations are already predominantly built for co-ordinated heat and electric power supply.

It might interest you that the Russian word for district heating corresponds to the English expression heatification. The conception is that in analogy with electrification all factories and all buildings of a town should be supplied with heat from electric power stations.

It can already be visualised that the fuel position in this country will also stimulate the introduction of district heating on a very large scale and this, I think, would be the best solution of the smoke abatement problem. From the town of the future the burning of coal, especially in small quantities, should be entirely eliminated, and the

total heat required for heating or manufacturing purposes generated in heat electric stations situated, as far as possible, outside the town.

Mr. J. W. YOUNG said :

Smoke, whether from an industrial plant or from a domestic chimney, to an engineer, is almost a direct measure of inefficiency, a fact which has been recognised by the use of instruments indicating the density of the smoke, in order to correct combustion conditions. The major causes of excessive smoke or, in other words, unburnt carbon are : (a) poor design of the grate or furnace, (b) inaccurate regulating apparatus, and (c) bad operation, although it is unfair to criticise operation where grate or furnace design is poor, or inaccurate control gear is fitted.

In industrial plant operation, hand fired coaling and damper baffling for air and flue gas regulation are certainly not accurate tools for this purpose. The average British workman is probably the best artisan in the world and, given the proper tools, will produce the best possible results, but are we giving him the tools ?

In order to follow correct operation, it is well to compare a boiler plant to any mass production factory where the rate of flow of the feeder sections must be correctly co-ordinated to bring an even stream of the component parts to the assembly line. *Smoke*, then, is due to the periodical over-feeding of coal or under-feeding of air. Thus it follows, to a large extent, that the control of an evenly regulated rate of flow of the services is the fundamental factor upon which efficient combustion depends. It is therefore suggested that carefully designed control, preferably inherently co-ordinated, is the ideal solution if *smoke abatement* in industrial boiler plants, however small, is to be achieved.

Modern practice shows that even for small boilers the application of automatic stokers, induced, forced and secondary air, all subject to central control, gives increased efficiency and the consequent improved fuel economy. The elimination of smoke is one of the many benefits arising out of this increased efficiency. Vast numbers of boilers, however, all have their services working on the old lines, and I suggest

that one of our endeavours should be to effect a large reduction in the number of these less efficient plants.

Domestic smoke abatement, on the contrary, cannot be so readily dealt with in this manner, as it is not economically possible to install control apparatus, nor is it humanly desirable to depend on skilled operation. If progress is to be made we have, therefore, to concentrate on (a) design of the fire-grate, (b) the type of fuel used, or preferably a combination of both. Legislation could probably insist upon cokes or non-smoking fuels only being used, but it is more than probable that bureaucratic control, especially in the home, will be most unpopular in the post-war period. Therefore it is upon grate design, possibly with the use of smokeless fuel, that the progress of smoke abatement appears to promise most hope of success.

It must, however, be clear that neither smokeless fuels nor more efficient grates will become popular unless some financial gain or decided increase in domestic comfort over that of the standard house fire can be demonstrated, and since the price of smokeless fuels does not appear to show any direct financial saving, then the grate must be designed to show clearly improvement in domestic comfort.

During an investigation into domestic heating and air conditioning some years ago, it was established that the difference in pressure between the air inside and outside the room is the governing factor in domestic comfort. So let us analyse the cause of this pressure difference with a normal sitting room. The pressure in the room with the usual standard fire-grate is reduced by the demand for air for combustion and by chimney draught, both of which affect exhaustion from the room. On the other hand the only means for make-up is through the openings between the floor boards and skirtings, or under the doors or window frames, and as these openings are small, cold external air blowing through, causes draughts across the lower portion of the room, on its way to the fire and chimney entrance, i.e. in the region of the comfortable chairs. Thus if means are taken to raise the room pressure

and to balance the pressure difference draughts will be eliminated and room heating will be more uniform.

Referring again to the industrial boiler plant where forced draught is applied to the underside of the fuel bed as primary air, and secondary air is supplied above the fire to enable combustion to be completed, so in our improved domestic fire-grate we will take our air for primary combustion from under the floor boards, and a further supply of air through the fire back for secondary air. Furthermore, we will take a third supply of air, heat it from the waste heat of the fire surround and chimney base and discharge it to the room as warm air.

With a fire grate designed on these lines, that is to say, having a heater delivering additional air to the room, the pressure in the room is increased, with the requisite elimination of draughts and increase in domestic comfort. Moreover, this increase in pressure, together with the primary air below the grate, improves the fire draught, and as the secondary air introduced above the fuel bed enables the excess carbon of household coal to be consumed, any type of solid fuel may be used.

Thus the fire, under these conditions, in addition to being capable of burning any smokeless fuel, will burn soft coals with a minimum of smoke discharge from the chimney. This type of grate is most suitable for smoke abatement, as, while it will burn any type of fuel, it will tend to burn away soft coal at a higher rate making this type of fuel uneconomic.

The Chairman of the North Western local centre of the Institute of Electrical Engineers has suggested in his chairman's address that one of the probable solution for domestic fuel economy is to ensure by legislation that only apparatus of approved design is allowed in post-war building and this seems also to be a most effective proposal in dealing with domestic grates and smoke abatement.

Mr. T. E. BIRTWISLE, M.B.E., said that, with his Vice-Chairman, he represented the Urban District Council of Castleford, and that he also represented, officially, the Sanitary Inspectors' Association.

is one which will have to be tackled fundamentally.

Fourthly, so far as the ways and means for developing and advancing the agreed proposals of the Society are concerned, some aspects of this question have been dealt with by previous speakers. Suffice it to say that meantime the attitude of the Society must be one of taking time by the forelock and being in the field early so that full advantage may be taken of the enthusiasm complex in reconstruction.

The discussion was then closed and the Conference discussed the resolutions that were submitted for consideration. It was agreed that in view of recent developments it was not the most opportune time to adopt a resolution on the lines of that proposed by Mr. Law, nor that there should be a resolution concerning colliery spoil-banks, as proposed by Mr. Robinson.

After amendment and additions the draft resolutions were finally adopted as follows :

RESOLUTIONS

(1) For Submission to H.M. Government and Ministries

That this Conference, recognising the very considerable advances in the prevention of air pollution that can readily be attained during reconstruction, calls upon the Government to give the problem the urgent and full attention that it warrants, for the purposes of materially improving public health and amenities, reducing a gross economic waste and assisting the better utilisation of our fuel resources.

In particular the Conference urges :

(i) That the Ministry of Health and the Ministry of Works consider the requirements and means to ensure smokelessness in all new housing.

(ii) That the Ministry of Health and the Ministry of Fuel and Power consider legislation to ensure that all new installations of fuel-burning plant shall be efficient for their purpose and capable of being operated smokelessly.

(iii) That the Ministry of Fuel and Power, in considering the development of the nation's fuel and power resources, plan for the increased production and most efficient distribution of smokeless forms of fuel and power, to provide at first for the needs of new and reconditioned housing and other building, and in due course the abolition of smoke from existing sources.

(iv) That the Ministry of Transport and the Ministry of Fuel and Power in every consideration of the question of post-war electrification of railways give the fullest recognition to the important reduction in air pollution that will accompany every extension of electrification, both suburban and main line ; and that this factor be also taken into account in considering the encouragement of electrically driven public service and other vehicles.

(v) That the Ministry of Town and Country Planning consider legislation and administrative requirements to make possible the establishment of smokeless central or other zones in towns.

(2) For Submission to Local Authorities

That Local Authorities throughout the country be urged to appoint special smoke abatement committees for the purpose of ensuring that full local examination of the problem in relation to reconstruction, and recommendations for action, may be made, with particular regard to town-planning, the establishment of smokeless areas, the zoning and control of industrial establishments, and the smokelessness of new housing ; and that, further, Local Authorities be requested to support the efforts of the National Smoke Abatement Society and the Regional Smoke Abatement Committees in making appropriate representations to the Government.

GENERAL PUBLICATIONS

of the National Smoke Abatement Society

(See over for post-war planning publications)

Smokeless Air.—The Society's quarterly journal (temporarily three times a year). The only magazine in the world devoted to the problems of air pollution. Gratis to members or 2/6 per annum, post-free.

Law of Smoke Nuisance.—By W. R. Hornby Steer, M.A., LL.B., Recorder of South Molton, Standing Counsel to the Society. This book, based on an earlier work by Randolph A. Glen and revised and extended in accordance with the Public Health Act of 1936, may be accepted as a standard work on the subject. In addition to the explanatory chapters, it contains tables of statutes and cases and the relevant sections from the two Acts and the Local Government Act, 1933. 8vo. 64 pages. 1/- paper backed ; 2/6 cloth bound.

The Case Against Smoke.—A booklet intended to give the reader a clear understanding of the nature and extent of the smoke nuisance by means of passages from a number of writers and speakers, each of whom is an authority in his own sphere. Also figures and extracts from official reports and tables. 24 pages, 4to. Price 3d.

Science Museum Exhibition. *Science Museum Exhibition, 1937-1938*

Handbook.—This is not only a detailed guide to a scientific exhibition, but, containing a series of twelve authoritative articles on the main aspects of the problem, is a permanent and useful reference book. 80 pages, medium 8vo. Price 6d.

Conference Report.—The most complete review of the problem to be published for many years. Twelve papers and discussions in full. 116 pages, 4to. Price 2/-.

Fumifugium : or the Smoke of London Dissipated.—By John Evelyn. This fascinating book, published in 1661 by the author of the famous diaries, has been republished by the Society, with an introduction by Rose Macaulay. This indictment of the smoke evil remains true, eloquent and penetrating. With original wood engravings and a portrait of Evelyn. Paper covers, 6d ; cloth-bound, 1/6.

Smoke and Fumes Nuisances from Road Vehicles.—The technical and scientific aspects by Dr. J. S. Owens, and the legal position by R. P. Mahaffy. 16 pages, 8vo. 3d.

The State of the Atmosphere.—A valuable and informative paper by the late Sir Frank Baines, F.R.I.B.A. With a section on the effects of smoke upon building stone. Royal 8vo. pp. 36. 6d.

Smoke and Aviation.—A full report of a special conference on this now topical subject. 40 pages, 8vo. 6d.

Smoke Abatement and Fuel Economy in Steam Boiler Practice (Published by the Manchester and District Regional Smoke Abatement Committee). 12 pages, 1d., by post, 2d.

Britain's Burning Shame.—This pamphlet has been described in a review as "a masterpiece of modern popular propaganda." It puts the smoke problem in its simplest terms, especially as it affects the home, and is profusely illustrated. Single copies, 2d. 12/6 per hundred.

Conference Proceedings.—Copies are available at 1/- each of the full reports, containing papers and discussions, of conference held in 1932, 1934, 1937 and 1938. Others are out of print.

All obtainable direct from the Society, post-free

The Society's Publications on POST-WAR RECONSTRUCTION

Memorandum on Smoke Prevention in Relation to Initial Post-War Reconstruction.

The Memorandum submitted by the Society to the Government Departments concerned, which sets forth proposals by means of which, it is claimed, practically the whole of the post-war building could be made smokeless. 24 pages. By post, 2d.

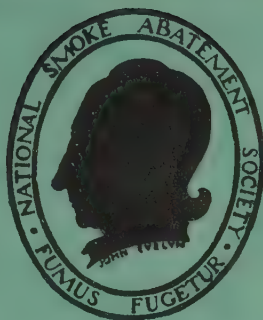
No Clean City.

An illustrated pamphlet showing the need for smoke prevention in post-war reconstruction. This is in effect a supplement to the memorandum described above. 16 pages. By post, 2d.

Plan for Clean Air.

An easily read outline of the Society's proposals and the "Ten Year Plan" in the form of a "quiz" of twenty questions and answers. A useful publication to hand to the uninformed. 8 pages. By post, 2d.

These publications are available in quantity at reduced prices. 1/6 per dozen; 10/- per hundred. We invite local authorities and others to help in their effective distribution



**NATIONAL SMOKE
ABATEMENT SOCIETY**

Programme for the
GENERAL MEETING
and CONFERENCE
on 5th November, 1943



To be held at the
CAXTON HALL
WESTMINSTER
S.W. 1

Programme



10 a.m. GENERAL MEETING

(For Members and Representatives of
Affiliated Members only).

AGENDA.

1. To adopt the Minutes of the previous meeting.
2. To receive the Annual Report.
3. To receive the Annual Statement of Accounts.
4. Election of—
 - (a) President.
 - (b) Vice-Presidents.
 - (c) Honorary Treasurer.
 - (d) Elected Members of the Council.
 - (e) Executive Committee.
5. Any further business.

11.15 a.m. CONFERENCE.

Chairman for First Session :
Sir Lawrence Chubb

(1) **“The Purpose of Planning—
and of Clean Air”**

Address by

**Clough Williams-Ellis, Esq.,
M.C., J.P., F.R.I.B.A.**

- (2) Statement on behalf of the Executive Committee (to be circularised in advance).

12.15 p.m. Adjournment for Lunch.

1.45 p.m. Chairman for Second Session :

E. H. Keeling, Esq., M.C., M.P.

*(Chairman, Greater London Advisory
Council for Smoke Abatement).*

General Discussion based on the
Executive Committee's Statement.

Among the speakers in the discussion
will be included :—

Miss Elizabeth Denby, Miss Caroline
Haslett (*Electrical Association for Women*),
Dr. E. W. Smith, Dr. R. Lessing,
V. W. Dale, Esq. (*British Electrical De-
velopment Association*), J. W. Beaumont,
Esq. (*West Riding of Yorkshire Regional
Smoke Abatement Committee*), Dr. J.
Johnstone Jervis (*City of Leeds*), F. J.
Redstone, Esq. (*City of Bristol*), L.
Hardern, Esq. (*Gas Light and Coke
Company*), Dr. G. E. Foxwell, A.
Margolis, Esq., J. W. Young, Esq.

4.30 p.m. Adoption of any Resolutions and close of
(approx.) Conference.

Please note :

1. Members and Delegates who wish to speak in the discussion are requested to inform the Secretary in advance. In view of the limitations of time it is hoped that no contribution will exceed ten minutes.
2. It is hoped to publish either a full or condensed report of the proceedings, and all speakers in the discussion are requested to let the Secretary have a copy of their remarks either before or after the meeting.
3. Since the issue of the preliminary notice the Society has removed to offices in London and the address for all communications is :

**Chandos House,
Buckingham Gate,
Westminster, S.W.1.**

ARNOLD MARSH,
General Secretary.

CLEAN AIR AND SOLID FUEL

Paper to be given by Mr. M. J. Edwards
(Director of Industrial & Domestic Sales, National Coal Board)
to the Conference of The National Society
For Clean Air, October 1970

CLEAN AIR AND SOLID FUEL

Paper to be given by Mr. M. J. Edwards
(Director of Industrial & Domestic Sales, National Coal Board)
to the Conference of The National Society
For Clean Air, October 1970

CLEAN AIR AND SOLID FUEL

1. So much effort has been concentrated this year on bringing supply and demand for domestic solid smokeless fuel into balance, that I have assumed that the main interest of delegates will be in a plain statement on the background to the present difficulties, on what has been done for next winter and, most important, on the prospects for the next 3–4 years. This paper, therefore, concentrates on the domestic market and I have only briefly mentioned developments in other markets. This is not to discount their value but it is the domestic issues which are most pressing now.

Perspective

2. Some key figures to put solid smokeless fuel into perspective:
- 50% of the heat supplied to the U.K. domestic fuel consumer (and this includes fuel for cooking and lighting) is in solid fuel and about a third of the heat supplied in Smoke Control Areas is solid smokeless fuel.
 - Householders spend about £350 m. on solid fuel (11% more than Marks & Spencers' turnover) and half of this is on solid smokeless fuel.
 - In 1969/70 almost £55 m. was spent on solid fuel heating appliances and systems; virtually all of this was on appliances capable of burning smokeless fuel and two thirds was on roomheater systems.
3. Solid fuel therefore is of crucial importance for keeping houses warm and Smoke Control Areas smokeless. The domestic market and smokeless fuel are vital to the Board's revenue and to thousands of private enterprise coal and builders merchants, installers and equipment manufacturers. It is because of this profound interdependence that the current supply difficulties have caused such embarrassment to the government, local authorities, private industry and householders, and to the Board.

Background

4. For several years, forecasts of demand for solid smokeless fuel in 1970/71 have differed. The Board's estimates have put demand at a relatively high level because we considered that the practical problems of introducing natural gas would be serious, that the strength of the roomheater in the market was very sound and that in general the domestic heating market is less receptive to change than is often assumed. Other estimates, including the Ministry estimates, assumed rapid penetration of the market by natural gas and that demand for solid smokeless fuel would slide in face of the attack. In general therefore, most estimates of demand have been below

those of the Board. In fact, demand in 1970/71 will be at the level forecast by the Board.

5. Supplies during 1970/71 on the other hand will be lower than expected and below demand. There are four reasons for this:

- (a) The major reason has been the rapid closure of coal based gas works. It has been known since January 1967 that the introduction of natural gas meant eventual closure, but the speed at which this has occurred has been greater than was expected. The past few years have seen a range of estimates of coal consumption at gas works in 1970/71. The Board have always stated quite explicitly both to the Ministry and publicly that too rapid a rundown would not allow sufficient time to provide capacity for replacement production. In fact, the programme finally tabled at the end of last year meant that actual coal consumption in 1970/71 would be at the lowest level ever mentioned as a possibility. As compared with a mid-way interpretation of the various official forecasts made in the past 3 or 4 years for coal consumption at gas works in 1970/71, this programme is really the equivalent of bringing forward the rundown by about 12 months. Although a reduction in production of gas coke, compared with 1969/70 was expected, this was now to be as much as 700,000 tons; but even more important than this were the devastating local effects of closures. The hardest hit is the North West. Until October last year, we believed that 700,000 tons of coal would be needed for carbonisation at gas works in the North West in 1970/71 and that this would produce about 350,000 tons of coke. In October we were informed by the Gas Council that the plans were revised and that only 25,000 tons of coal would be needed.
- (b) The Board's Roomheat and Homefire plants have so far failed to achieve their production capacity. On the other hand it has been no secret for 2 or 3 years that however desirable the fuels may be, there have been serious technical problems in scaling up from the pilot plant stage.
- (c) The British steel industry has enjoyed an unprecedented boom. They have wanted every ton of coke they could get for steel making and so they have virtually stopped all their traditional supplies to the domestic market and they have bought in coke from the independent producers. This has all had the effect of withdrawing from the domestic market between 100,000 and 150,000 tons of coke.

- (d) Finally, the reserve stocks upon which many producers, including the Board, had been gradually drawing, were exhausted.

Winter 1970/71

6. By the end of 1969, it had become obvious that there could be a significant shortage of smokeless fuels in the 1970/71 winter. It was difficult to forecast the size of the shortage with any precision; but after setting an increase in supplies from the independents and the Board against what we then knew of the intentions of the Gas Boards and B.S.C. and after making some allowance for some unsatisfied demand in 1969/70 and for growth in the market, we calculated that there could be a net total deficiency of just under 700,000 tons or 8% of total demand. Overall this might not appear too serious -- after all, 92% of demand would be met -- but the key issue was that in some Regions such as the North West, the deficiency would be really serious. Much the greatest impact would be on open fire smokeless fuel and this would hit the old smoke control areas which were primarily based on improved open fires.

7. There was not time to put up new production capacity to meet the deficiency. It takes 18 months to produce the simplest smokeless fuel plant. Coalite, for example, lost no time in announcing plans to fill quite a large part of the critical gap in open fire smokeless fuels. Even where these plans could be implemented immediately actual production of the fuel would not start until the beginning of 1971: where planning permission was required for the big new Rossington plant, although one Ministry clearly wanted the smokeless fuel, the local objections meant that another Ministry had no alternative but to order a public inquiry and the net effect of this was to delay the start of production by about 9 months to the end of 1971 or early 1972.

8. The situation clearly needed rapid action but such a combination of actions which only a Government could take. It is no secret that around the turn of the year, it was impossible to get the response which we felt the seriousness of the situation demanded; but the combined efforts of the National Society for Clean Air, the S.S.F.E., the Board and many others, with much public debate, were eventually successful and since late May action has been forceful. Six major steps have been taken:

More Production from Existing Capacity

- (a) All the established producers of smokeless fuel have been going flat out to get the maximum tonnage from existing capacity. The Board for example, are operating their Sunbrite ovens at about 110% of their rated capacity and we

have been successful in stepping up production of naturally smokeless fuel from both opencast and deep mines. Certainly the value of opencast coal workings has been clearly demonstrated during the past 6 or 9 months, with their considerable flexibility and ability to respond to demand, especially now that land restoration has reached such a high level that opencast working leaves behind it a net contribution to the environment rather than any damage.

Deferment of Gas Works Closures

- (b) We have all pressed for the deferment of gas works closures and, equally important, have tried to ensure that there is maximum output at the works which remain. It may be that, had a stronger line been taken earlier on this, we might have had better results, because in most cases the process of closure had gone too far. It has proved possible to make available an extra 170,000 tons of gas coke but of this probably only half will be supplied to the domestic market.

Fireglo

- (c) The Board are bringing in briquettes made in France from Welsh duff. The large French briquetting plants had immediate unused capacity. We have stocks of Welsh duff and to have this duff processed in France seemed the obvious way of getting immediate relief. The briquettes, sold as Fireglo, are of high quality, similar to Multiheat; and the majority are being brought into the South, South West and the North West.

Converting non-domestic boilers from coke

- (d) About 2 million tons of smokeless fuel – about a third gas coke and most of the remainder suitable for the domestic market – are being used on non-domestic space heating boilers, nearly all of them operated by national and local authorities and some of them quite large. In many cases, these boilers can be adapted to burn industrial coal smokelessly or small anthracite. Hand firing of coke on this scale is archaic and expensive and because of this, the process of conversion has been going on for many years. The gas coke is disappearing and the remainder would be better utilised in the domestic market; and for these reasons, local authorities and the major Ministries involved have been asked by the Government to speed up this process of conversion to get as much as possible done by next winter,

and the remainder by the winter following. The need to carry out more rapid conversion has undoubtedly upset many local authority budgets and has imposed a further burden on their management, but we have certainly endeavoured to ease the problem as far as possible. We have offered to finance the change so that local authorities will not have to find capital but can pay for it from the savings in running costs. Our technical and commercial service is at the disposal of local authorities, to prepare schemes for changing and if local authorities wish, we will act as main contractors for the work.

Deferment and Suspension of Smoke Control Orders

- (e) Local authorities have been asked by the Government to defer new Smoke Control Orders and to consider the suspension of some of the existing orders. Both courses are most regrettable and the latter is particularly unpalatable to those local authorities who, with great initiative and expense, made some of the earliest progress on Clean Air. There is no alternative, because there is no other smokeless fuel available to replace the improved gas coke used on the open fires of the earliest Smoke Control areas. On the other hand, the need for suspension will vary from Region to Region and will be concentrated in those where the withdrawal of gas coke has hit hardest; the suspension of Smoke Control Orders will be for a clearly defined period, and finally, we believe that householders in these areas where Smoke Control has been temporarily suspended, will not revert 100% to house coal. They will use smokeless fuel when they can get it, and the merchants have undertaken to deliver bituminous coal only when they have no smokeless fuel, and then in small quantities. Really what we are guarding against is the mid-winter situation.

It would be quite wrong, therefore, to think that, regrettable as the suspensions are, the clock was being put back to 1956. In fact, the national consumption of house coal in 1970/71, despite making generous allowance for the effect of suspension of Smoke Control Orders, will be much less than in 1969/70.

New Contracts

- (f) Finally the Board have put their own house in order so as to be in the best position to face the winter. We had a complex system of contracts for smokeless fuel, with a paper commitment far in excess of what we could supply, or

ever have supplied. We considered that what merchants must know, is what they can realistically expect to get and when. We recontracted for all our own smokeless fuels in the middle of the year. The change has brought great improvement and in total, we expect to perform 100% of the contractual commitment during the present year. This sort of change does not increase availability but ensures the most efficient distribution of what there is and eases the merchant's task in advising his customers.

9. On the basis of these six actions, providing they are pressed to completion in the short time which now remains before winter sets in, we should achieve at least the first target. If conditions are anything like normal, householders using solid fuel will all be able to keep warm, but this may be at the expense of some additional smoke.

The Next Few Years

10. Although we have concentrated so much in recent months on the emergencies of next winter, in 6 months the supply and demand for smokeless fuel during the winter 1970/71 will be a matter of history. The really important issue which now faces us is that of the next few years.

11. With such a degree of interdependence between solid fuel and domestic heating, it is essential that existing demand for solid smokeless fuel is met; then extension of Smoke Control can be resumed and the solid fuel industry can supply its full share of the increasing requirements of domestic heating.

12. The heating standards considered satisfactory by the ordinary householder are definitely and clearly increasing – already they are well above Parker Morris standards. The Board identified these rising standards of the ordinary householder before any of the other fuels; set out to satisfy his needs and has done this successfully. The roomheater in particular, and also the improved open fire, heating up to 7-8 radiators, as well as providing ample domestic hot water, exactly meet the requirements of this market, with low operating costs and no risk of running up big quarterly bills before they know where they are, really constant heat, no condensation, good ventilation, a real fire in the living room, first class appearance, negligible maintenance, simplicity of operation and substantial construction for at least 15 years' life. Wherever the ordinary householder can exercise free uninhibited choice, solid fuel had done well, and with good reason.

13. To maintain and develop this market, we must demonstrate that the fuel they need will be there and, with few exceptions, this fuel must be burnt smokelessly. Confidence is the key motivation for

choice of heating equipment, which is relatively expensive and is expected to function satisfactorily for a long time; the buyer, whether householder or local authority, must be satisfied that on all the evidence available he is making a wise choice for the future. There is no doubt of the determination now behind the drive to fill the smokeless fuel gap and to give the householder the confidence to choose the fuel he wants. On plant producing conventional smokeless fuels, expenditure within the next three years will be in the region of £25 m., some of it by private companies new to smokeless fuel manufacture and, in addition, there is a massive programme of appliance development concentrated on burning ordinary coal smokelessly. The producers are therefore demonstrating their confidence in the future in the most convincing way possible.

14. It is easiest to look at the next few years in three sections, dealing with open fire smokeless and closed appliance smokeless fuel separately, although there is some overlap between the two, and then giving an up to date view of the domestic appliances which burn bituminous coal smokelessly. It is important to stress that I have based this view only on known plans, now in course of implementation, and I have deliberately omitted anything not firmly decided upon.

Open Fire Smokeless Fuel

15. There is a current demand for nearly 3 million tons of open fire smokeless fuel and this has been more or less adequately met until this year. About 1 million tons, or 33% of total supplies in 1969/70 was in the form of improved gas coke and this will have been phased out by 1973 on present plans. This rundown has already begun in earnest and it is in the supply of open fire smokeless fuel that the cutback in gas coke production has hurt most. On the other hand it is here that new capacity will come into production quickly and in large tonnage. We have 4 major sources of new production. On plans now being implemented, production of Coalite large will be increased by about 500,000 tons over the next 2 years and Rexco large by about 100,000 tons, as compared with last year. There are plans to produce open fire smokeless briquettes of various types and output here could be around 100,000 t.p.a. Furthermore there is a large, if not as yet realised, potential in our Homefire and Roomheat plans. On the basis of the additional production of Coalite, Rexco and other briquettes and assuming only a moderate improvement in production from our own two plants (improvement which is now taking place), then the shortfall in open fire smokeless fuel arising from the reduction in gas coke production, should be fully made up, without taking into account further plans in the pipeline. The most critical thing here is timing. Because of

the delay of the public inquiry, Coalite's big Rossington plant is now unlikely to start production before the very end of 1971 or early 1972. For this reason it is essential that production of improved gas coke is maintained on the highest possible level throughout the coming year.

16. This is then the picture on supply. On demand, there is likely to be a continued trend towards substitution of open fire smokeless fuel for bituminous house coal and the important new market for solid fuel in the luxury open fire will undoubtedly bring more demand for smokeless fuel. However, total demand for open fire smokeless fuel on present trends over the next few years, is not likely to change and may in fact drift down a little. This is because this market is particularly affected by demolition; there is a large tonnage used in older local authority housing which is coming up for rehabilitation; and finally in both local authority and private housing it has hitherto been common to replace open fires as soon as householders decide that they want a certain amount of central heating.

17. By 1972 therefore the producers will be as keen as ever to secure all the business they can for open fire smokeless fuel.

Closed Appliance Smokeless Fuel

18. In round figures, the supply of closed appliance smokeless fuel last year was about 5.8 million tons. Nearly 500,000 tons of this in the form of gas coke will disappear by 1973 if present plans go through, and there will be a further loss of 300 – 350,000 tons on account of the cutback in B.S.C. coke supplies and the exhaustion of our own coke stocks. As compared with last year, therefore, we have a total loss of about 800 – 850,000 tons to make up by 1973. On present plans, we should be able to do this quite comfortably.

- This year we should have additional production capacity of over 300,000 tons, mainly from increased production of anthracite, Phurnacite, Rexco nuts and Fireglo.
- In 1971/72 we are expecting a further 350,000 tons from more production of Phurnacite and Rexco and Coalite nuts and from two new briquetting plants.
- In 1972/73 there should be still a further 350,000 t.p.a. from new briquetting plants.

In total, therefore, there should be additional production capacity by 1972/73 of about 1 m. t.p.a.

19. The position on demand is equally important. During recent years, the total supply of closed appliance smokeless fuel to the domestic market has not changed very much in total, but there has been a drastic alteration in the shape of the market. A large number of the domestic independent boilers using the nut sized smokeless fuel, have come up for replacement and many have not been replaced

by appliances burning similar fuel. All the tonnage which has thereby been made available, however, has been taken up by the installation of a really vast number of new roomheaters. This exchange operation has proceeded quite happily within much the same total availability. This steady replacement of independent boilers using the nut sized smokeless fuel will certainly continue over the next few years, and in total, all boilers of this type use about $2\frac{1}{2}$ m. t.p.a. at present. Not only is there the prospect of continuing change within the domestic market itself, however, but in addition, we supply about 2 million tons of smokeless fuel, mainly suitable for the domestic market, to non-domestic heating. Two thirds of this is in fuels other than gas coke, that is, fuels from continuing sources of production. This market is very short term and by early 1972 can be expected to fall to around 1 million tons with some continuing reduction thereafter.

20. From two sources therefore – from the replacement of domestic independent and non-domestic space heating boilers now using nut sized smokeless fuel, substantial tonnages will be released. At the same time the reduction in gas coke supplies will be much more than made up from new capacity over the next 2 – 3 years. There will certainly be differences of emphasis from region to region but overall there is no doubt that there will be ample headroom for the resumption, after next winter, of the installation of roomheaters at the same rate as that of the past couple of years, especially if we can achieve a sensibly ordered programme for closing the remaining gasworks, so that the new production capacity can be introduced to the market in the most efficient way.

Conventional Smokeless Fuels

21. Industry, both public and private, has responded fast to the acceleration of gasworks closures. Even on present, firm scheduled plans, the phasing out of gas coke should be replaced with new capacity, and supply and demand for solid fuel in total should come back into broad balance during 1971, particularly in the second half of the year. There will however, be some problems in equating supply and demand regionally, because of the changed pattern of production and these will require marketing skill to sort out. The first sectors of the market to come into balance are likely to be South Wales, the South East, South West and West Midlands, where Welsh fuels can be most easily marketed, and where a high proportion of the demand is for closed appliance smokeless fuels; the problems in the North West and on the North East coast, however, will take longer to sort out. The North West is unlikely to be brought into balance until the Coalite plant at Rossington begins operation.

22. All the new capacity is intended by the investors to operate at full capacity for the foreseeable future and it is of major impor-

tance that the new capacity is smoothly geared in with the closure of coal based gasworks. Not only can householders and local authorities not face any repetition, even on a smaller scale, of the present difficulties, but the producers, both private and public, cannot allow public confidence in solid fuel to be undermined as it has been recently, because their investment would be placed in jeopardy. It is therefore essential that the remainder of the coal based gasworks are phased out in an orderly way and that all the interested parties, including the Society, are not only informed well ahead, but are allowed to put their views to the Ministry before any irreversible decisions are taken and that the Ministry take responsibility for seeing that the overall national interest is observed.

Smokeless Combustion of Bituminous Coal

23. One of the most important prospects for the future of Clean Air, is the commercial development of smokeless combustion of bituminous coal on domestic appliances. The successful conclusion of this would have a revolutionary effect. One large pit can produce 300,000 or 400,000 tons a year of the $\frac{1}{2}$ " \times $1\frac{1}{2}$ " coals that these appliances require. Little processing is required above the washing and screening that is done already. The fuel is, therefore, cheap per ton and used, as it will be, at a high efficiency, running costs can be cut to a level which have not been seen in the domestic market for 10 years. Local authorities will be able to press forward with smoke control in the knowledge that not only is fuel available for smokeless zones in really vast tonnages but that running costs will be below anything else available – smokey or smokeless. They will know, therefore, that smoke control will reduce householders' heating costs, even if they are using house coal, rather than increase them, and in the coalfield areas, in most cases, local coals will continue to be able to be used by householders. In this respect alone, it could be a major breakthrough for clean air. The Board, in conjunction with appliance manufacturers, has been developing both boilers and room heaters embodying this principle.

Boilers

24. There has been one boiler on the market commercially for a year. A relatively specialised piece of equipment, the Triancomatic, produced by Trianco, is an automatically stoked 80,000 b.t.u. boiler. The bigger version producing about 100,000 b.t.u.'s is in the process of development. These boilers are fairly expensive and require certain site conditions to operate satisfactorily but there is a big reward in exceptionally low running costs, particularly in the coalfields.

25. Of wider interest in the boiler market, is the gravity feed boiler. The model now under development produces about 60,000 b.t.u.'s. In every way, except that it uses bituminous coal, it is very similar to

the tried and tested anthracite gravity feed boiler. Because of the low first cost of the coal, however, running costs are exceptionally low. This will be undoubtedly by far the cheapest way of heating the bigger private house, outside South Wales and the West of England. In the Midlands and Yorkshire, we are talking about all-in running costs for up to 10 to 12 radiators, and including hot water in the Summer, of about £55/£65 per year. Providing field tests are satisfactory these boilers should start to be available in the Spring. It is likely that then marketing will commence on a regional basis but be gradually extended to cover most of the country, except probably South Wales where suitable coal is not readily available, but where there are ample supplies of anthracite grains. Work is also planned for a larger version of this boiler producing about 75,000 b.t.u.'s.

Roomheaters

26. In terms of potential sales, the Roomheater is the most important appliance under development. After a great deal of basic research an appliance which is now known as the Housewarmer was evolved to a stage where it could be commercially manufactured, about 18 months ago. In view of the novelty of the appliance, however, we decided that we should take care to test-market it because the essential factor is how it performs in the ordinary house. We have had about 1,400 of these appliances installed in ordinary houses and, on the basis of this experience, we can say with no doubts that the combustion principle does work in the hands of the ordinary housewife. On the other hand, experience has identified certain features which must be altered before the appliance can be commercially marketed. First of all, the original Housewarmer was designed at a time when public demand was for an appliance producing about 28,000 b.t.u.'s an hour, that is to say Parker Morris standards; but public demand for heating has since increased quite sharply and the appliance is now inadequate to meet probably the major growth section of the market, where typically, around 33/38,000 b.t.u.'s is wanted. Secondly, the original appliance had certain design features which proved to be vulnerable to heavy usage. We are very keen to maintain the reputation that solid fuel appliances have, of being able to withstand very heavy usage over a long period, without significant maintenance. The economic life of traditional roomheaters is at least 12 to 15 years and we want any bituminous coal-fired appliances to perform equally as well. This is a major attraction of solid fuel for local authorities as compared with other fuels. Finally, the appearance of the Housewarmer is not up to the first class standards now being set by the traditional roomheater.

27. Based on the experience we have now secured in the field, two new appliances have been designed and should be available in 1971. Firstly, there will be an appliance producing about 32/33,000 b.t.u.'s, able to provide ample Parker Morris standards in houses of modern construction and secondly, a bigger unit producing about 38,000 b.t.u.'s which will provide whole house heating for the older local authority house and for the traditional 3 bedroomed older private house. These appliances we are sure will perform well and look good.

28. We are taking this opportunity to offer a new standard of service with the new roomheaters. We will be basing this operation on the supply of pre-packed fuel. The economics of pre-packing coal are difficult because the ratio of bulk to price is so high—of all the domestic requirements, coal is the cheapest per lb. (a 1½d or so a lb. is a typical price). We believe, however, that packing of the small graded coal required for these appliances can be carried out really economically. This brings real advantages:

- It ensures that the right fuel in the right condition is delivered.
- The bags are clearly marked for use on these appliances only, in smoke control areas.
- It means that methods of delivery to customers can be changed fundamentally and much greater customer satisfaction ensured.
- The bags are easy and clean to store.

29. These bituminous coal fired appliances must fully satisfy the legal standards for exemption. We regard it as equally important that they should satisfy the practical requirements of local authorities. Our experience with the appliances during the test market period, indicates that we are at least 90% there as far as this is concerned. The principle of combustion has passed well and the shortcomings are mainly due to mishandling. With the new appliances now under development we are concentrating on minimising the temptation and the ability to mishandle. With the increased capacity, the temptation will be reduced to no more than that with any other appliance and with the alterations to the engineering design, the householder will be far less able to mishandle it. It is our aim that these appliances should be no more vulnerable to mishandling, with resultant production of smoke, than any other solid fuel appliance. We have no intention of placing any extra burden on local authorities for policing smoke control areas.

30. The successful development of these appliances is of major importance to the future of Clean Air and particularly to the speed and ease with which smoke control can be extended into the coalfield areas.

District Heating

31. District heating provides domestic heating in a way which is especially attractive to all those keen to see atmospheric pollution reduced, because it combines what the ordinary householder wants—first class heating at a standard essential for the future, but at a price which the householder can afford now—with a single high level emission of flue gases from plant under professional control.

32. District heating has been extensively used in the past 30 or 40 years in the colder parts of the world, particularly Scandinavia. Whilst they had developed most of the basic techniques (with the conspicuous exception of efficient metering), techniques cannot be seen in isolation from economics and it has been primarily economics that have prevented the development of district heating in this country. There have been three main factors—our relatively temperate climate, the fact that domestic and industrial fuel prices were generally much closer in the U.K. than on the Continent, particularly after the war, and the traditionally low U.K. housing density. These factors have been slowly changing over the last decade. Although our weather is still the same as ever, the standards of heating acceptable to the ordinary householder have been rising rapidly in the past few years and are clearly going to continue to do so, certainly in the short term. The gap between industrial and domestic fuel prices has also been widening somewhat. Finally many major local authority developments in the past 10 years have brought high densities to large areas of our cities. All this has meant that the case for district heating in the U.K. has become progressively more favourable. Clearly the essential move was for someone to take the plunge with a major district heating scheme, to see how the theory worked in practice under U.K. conditions.

33. In 1962 the Board backed the first district heating project in the country at Billingham, supplying both domestic and industrial consumers. This has been successful by any standards but particularly in view of the state of experience with district heating at that time in this country. Since then there has been extensive progress. There are already 66 major coal fired district heating schemes either finished or in the process of construction. The biggest district heating scheme in the U.K. is about to be started in Nottingham, jointly between the Corporation and the N.C.B., where conventional boiler plant will be combined with refuse incinerators to provide the heat, in this way also solving another long term environmental problem. This is a soundly based scheme, which is at the same time bold, and is a key project for the development of district heating in this country. Nottingham Corporation are certainly pointing the way forward with real emphasis. All these efforts are producing that vital accumulation

of practical experience and knowledge which is essential to future progress on a really wide front.

34. There is of course a great deal of work still to be done to map out all the potential in district heating in detail, but the essential structure for progress has been completed save for one aspect – the integration of electricity generation with heating from waste heat, giving a total efficiency far above that of electricity generation on its own. The Ministry of Housing and Local Government is at present carrying out a wide survey of the technical and financial aspects. Already there is a strong body of opinion which considers that on grounds of efficient electricity generation, there is now a real case for supplementing the big stations with small modern stations near to the centres of demand. Surely we ought to aim to tie these into district heating schemes and as we know from all the past experience in district heating, we will not get anywhere until we try out one scheme in practice.

35. At the same time important progress is being made on technical matters. In particular the Board have been supporting work on the very difficult problem of an efficient heat meter and it is likely that two really reliable meters will be developed to the commercial stage quite soon. Once this has been achieved and especially when each meter can be linked to some central point and automatically computed with the invoices printed as one operation, then the administration of district heating schemes will become far easier for all concerned – local authorities and the operating companies.

36. District heating has made more progress in the U.K. in the past 8 years than in the previous 30, because local authorities and the fuel industries were quick to realise that certain basic trends were changing; but they had to be prepared to take some risks in order to build for the future. No fuel industry has contributed more to the really pioneering schemes than the N.C.B., the N.C.B. is still in the forefront of district heating development with the Nottingham scheme and it intends to stay that way.

Industry

37. Because clean flue gases on coal fired plant are brought about by the high efficiency and low labour costs of mechanical stoking, much the greater part of the coal supplies to industry, even before the 1956 act, was in fact burnt on mechanical stokers. There were two important tasks remaining, however – the standards for the practical operation required of mechanically stoked plant, needed to be tightened up in a number of respects, so that optimum conditions achievable with mechanical firing were in fact achieved; and the sizeable number of small plants which were still hand fired with bituminous coal had to be mechanised.

38. The Board wholeheartedly joined in the task, because persuading people to operate their coal fired plant smokelessly, meant operating with maximum efficiency and thereby our commercial position in the market was safeguarded. With an extensive technical advisory service, the Board set out to make their special contribution to what is a major problem in British Industry – how to make the best use of the assets which we have inherited. Whilst there is a fashionable lamentation about the heavy burden which we have to carry because we were the first major industrial nation, with train tunnels designed to cope with the Rocket and docks built when 5,000 tonners were the biggest thing afloat, there is another side, in that we have inherited an enormous volume of industrial hardware which stands at a very low value in the books. The Board have always felt it a key challenge to see what could be done to bring existing boiler plant, 15 or 20 years old or more, up to a modern standard of efficiency, and thereby obtain another 15 or 20 years life at a readily acceptable standard of performance but at very little capital cost. This is most important, not only for Clean Air but for the whole economics of industry, because fuel costs are only a small contributor to total industrial costs, but boiler plants in fact absorb large quantities of capital which are then tied up for about 30 or 40 years. There can be little argument about the rapidity of the progress made over the past 15 years in modernising coal fired boiler plant, and in some cases truly amazing results have been achieved for very little capital expenditure.

39. The coal industry has been determined to achieve very high standards also, where the existing plant cannot be retained and new plant must be installed. This has included both the adaptation and refinement of long tried boiler types with the range of packaged chaingrate stoker boilers now available, and also boilers incorporating quite novel types of firing, coal handling and ash removal.

40. Of by far the greatest long term interest to the Society in this field, is the research programme now being undertaken on fluidised bed combustion. In terms of Clean Air, this programme of research, if successful, would have results far beyond the element of smoke removal. Coal already has the advantage that a substantial part of the sulphur in the raw fuel is retained in the ash. The fluidised bed technique, however, we always considered should bring retention of a much higher proportion of the sulphur. During the past 18 months our research organisations have been carrying out an important programme of experiments both in the laboratory and on the test rig, to prove various aspects of the theoretical assessment of the new technique. This has been done in co-operation with the National Air Pollution Control Administration, which reflects the very keen interest shown in the work in the U.S.A. This programme of work has demonstrated beyond doubt that the emission of SO_2 from the stack

can be reduced to negligible proportions by the addition of limestone or dolomite to the fluidised bed, at costs far below those of any other method of sulphur removal by large boiler plants. The programme has also indicated that corrosion and erosion problems should be less than for a conventional boiler; that a wide variety of coals can be successfully fired; that our hopes for automatic control appear to be feasible; and, most important, that the great advantage of higher rates of heat transfer are substantiated, enabling the size of the boiler to be reduced and with it, capital costs. Designs for full-scale plants have been obtained from a number of leading boiler manufacturers and these are now being appraised. They include a design for a 20 megawatt boiler.

41. Fluidised bed would represent the biggest change in boiler firing techniques for coal since pulverised fuel firing was introduced on a large scale after the war. There should be no doubt, however, that it is a very fundamental problem and it requires big resources and a long term view to follow it through successfully.

Conclusion

42. Although this year has seen real progress in the extension of Clean Air in many fields, in the domestic market it has been the most difficult period since the 1956 Act was passed, with all but a virtual standstill, and in some areas, temporary loss of ground.

43. Whilst other fuels will also have their difficulties in meeting demand this winter, what happened to the production capacity for solid smokeless fuels this year was quite unnecessary; the absence of overall planning for solid smokeless fuel based on accurate estimates of demand has harmed the soundness of a market which has been built up over many years at considerable cost in money, time and management to local Authorities and householders on one hand, and the producers of fuel and appliances on the other. This must never be allowed to happen again. The producers, both public and private, have reacted quickly with big investment in new capacity, but this must be introduced in an orderly way, closely geared to the phasing out of the remaining coal-fired gasworks. I am sure that the Society will join with the Board and the independent producers in seeing that this does happen.

44. Despite this year's problems, we can take some comfort that disaster is just as much an impostor as triumph and from these difficulties will come the biggest single increase ever in solid smokeless fuel capacity; and this capacity the producers intend to operate to the full for years ahead.

C 31
342

Proceedings of Conference
on

IMPROVED
FUEL BURNING
INSTALLATIONS
IN NEW HOUSES

London - 19th October - 1945

Contents

	<i>Page</i>
Chairman's Remarks	2
Address by Alderman C. W. Key, M.P., Parlia- mentary Secretary, Ministry of Health ...	2
Executive Committee Statement	4
Discussion	6
Resolution	10
Subsequent Action	11

NATIONAL SMOKE ABATEMENT SOCIETY
Chandos House, Buckingham Gate, Westminster, S.W.1

Price One Shilling

NATIONAL SMOKE ABATEMENT SOCIETY

Proceedings of a Conference held at the Caxton Hall,
Westminster, on 19th October, 1945

on

IMPROVED FUEL BURNING APPLIANCES FOR NEW HOUSES

The Chairman

The Chairman, **Councillor Professor F. E. Tylecote, M.D.** (Manchester City Council), in opening the meeting, said : It is a great pleasure to us to welcome to our Conference Alderman Key, the Parliamentary Secretary of the Ministry of Health, whose long and devoted service to Local Government assures us of his interest in the welfare of this Society. Perhaps it will not be out of place here to mention the valued support given to our objects in the *Housing Manual*, which support will, we confidently hope, be continued by the present Government.

The priority which is so rightly to be given to housing in the immediate future implies the purchase and installing of an enormous number of fuel-burning appliances in the new houses. This makes our problem a very urgent one. If out-of-date extravagant smoke-producing apparatus is made use of because it is more easily obtainable at the moment than are economical modern, smokeless appliances an error will have been committed which will not only waste much money, but will greatly injure the Public Health for probably a generation to come — because, once installed, these things will be allowed to wear themselves out.

Manufacturers must, however, be assured of a large demand if they are to apply themselves effectively to this problem and to so improve their patterns that we are continually getting greater efficiency together with a free supply of the best models. Alderman Key has to leave us shortly for another appointment, so I will now call on him to address the meeting, and reserve any further remarks.

Alderman C. W. Key, M.P.

Parliamentary Secretary, Ministry of Health

The Ministry of Health, as the Department concerned with the administration of the Public Health Acts, are, of course, particularly interested in any practical proposal which will have the effect of reducing atmospheric pollution, and as the Department administering the Housing Acts are also most anxious that up-to-date equipment of all kinds should be installed in new houses.

As far back as 1920 the Department issued a Circular to local authorities encouraging them to install methods of heating and cooking in their houses which would reduce smoke, and there is in the *Housing Manual*, 1944 (which was prepared jointly by the Ministry of Health and the Ministry of Works for the guidance of local authorities and others concerned) a chapter 'Heating Installation' on which the Ministry of Fuel and Power were consulted, in which the desirability of using methods of heating and cooking which would have the joint effect of reducing the emission of smoke and saving fuel is stressed.

It is therefore fair to say that the Government Departments concerned are not apathetic to the Society's aim, but are in fact doing everything that is practicable to secure an improvement in the position.

But the time is far from ripe for the Departments to advise the Government to promote legislation to compel the installation of smoke reducing appliances in all

new houses, or even to make it a condition for the grant of a housing subsidy to local authorities that they should install such appliances in their new houses.

The ideal heating and cooking arrangements from the point of view of smoke abatement are those derived from gas or electricity, and the extended use of them should be encouraged in areas where they can be provided at a reasonable cost as compared with other forms of heating and cooking. But it will be readily realised that any great increase in the demand for the use of gas or electricity would upset the economics of the industry. One advantage of solid fuel is that it can be stored against cold spells, whereas if all heating and cooking were dependent on gas or electricity it would be necessary to provide a big reserve of plant for peak periods of consumption, much of which would be idle in the summer. It must be borne in mind that there is a very strong liking for or prejudice in favour of an open fire, and most people prefer this method of heating with its cheerful sense of comfort and well-being despite the extra domestic work it entails. Moreover, on the grounds of cost alone, the use of gas and electricity cannot compare with the facilities provided by the use of solid fuel.

The solution to the problem then, if the advantages of the open fire are to be retained, is the use of smokeless fuel, or to develop methods of burning bituminous coal whereby smoke is reduced to a minimum. There are, however, limits to the use of smokeless fuel. The supply of naturally smokeless fuel is relatively small as also is carbonized fuel, and the latter is not likely to be produced in sufficient quantities to make an important contribution to smoke abatement in the near future. It is probable that the better cleaning and preparation of coal is the right approach to an increase in the production of smokeless fuel. There were, of course, many grates on the market before the war which burnt smokeless fuel, and in some of them bituminous coal could also be used, provided that it was mixed with smokeless fuel and care was taken to avoid sooting up.

The most useful appliances from the point of view of smoke abatement are those in which bituminous coal can be used and smoke avoided. Much has already been done in the way of research for new appliances, and some are being developed by the appliance manufacturers. It cannot be said, however, that the ideal appliance has yet been found, and investigations are being actively pursued.

In this connection it might be of interest to the conference to know that a small exhibition of housing equipment arranged by the Ministry of Works at Church House, Westminster, includes specimens of modern grates, which are being recommended to local authorities:

It will not be possible to put new models into production immediately as skilled labour is lacking in the iron foundries for this purpose, and for an interim period, if the housing programme is not to be held up, some manufacturers can only make available their old models. It is hoped that the period will be kept as short as possible, and in the meantime efforts are being made to secure that only the most efficient of the pre-war appliances are selected.

Manufacturers are loth to embark on the production of new models until they have some idea of the demand for them. The Government are considering production agreements or bulk purchase schemes in respect of new fittings, in order to get them going, and if this is arranged, the most up-to-date fuel-burning appliances are likely to be included in the scheme. This is, however, the responsibility of the Ministry of Supply.

It is, however, not considered that this delay in introducing the more modern appliances will be a great aggravation of the smoke nuisance. The thousands of temporary houses which are going up in different parts of the country are being equipped for heating and cooking by gas or electricity, and the only fire grate which is being installed is designed for the avoidance of smoke. It is safe, too, to assume that a proportion of the new permanent houses will have the more modern grates installed.

Local authorities in all probability will be the largest builders of houses in the next two or three years, and they can, by arranging, wherever possible, for the provision of modern heating and cooking facilities in their houses stimulate the production of efficient solid fuel-burning appliances.

However, until efficient grates are readily available in sufficient quantities and at a reasonable cost there can be no question of compelling their installation by legislation.

Executive Committee Statement

A statement, expressing the views of the Executive Committee, had been distributed among those present, and was taken as read. It was as follows :

This Conference has been called in the hope that it may assist in clarifying and helping to improve the position with respect to the installation of new types of fuel-burning appliances in new houses, by means of which both fuel economy and smoke prevention may be promoted. It is hoped that the statement made by the Parliamentary Secretary to the Ministry of Health, and contributions to the discussion by representatives of local authorities and by those concerned with the manufacture of appliances and the production of fuels may, together, have a constructive and mutually helpful value.

The Society's own concern and policy in this matter may be briefly stated. The Society exists only to promote smoke abatement, or as many would prefer to say, smoke abolition. We are anxious that the new houses to be erected shall take full advantage of the means for preventing smoke that are to-day available, and shall not, by the installation of smoke-producing appliances, extend and perpetuate the evil.

The attention that it is necessary to give to solid fuel appliances should not obscure the fact that a substantial part of domestic smoke prevention can and should be achieved through the greater use of gas, electricity, and, in appropriate new districts, by district heating. While, however, there remains a demand and an economic need for open fires and other solid fuel appliances, it is essential that these should be suitable for smokeless fuels.

It is not practicable at the moment, to propose general regulations to prevent smoke emission from private houses or to restrict the types of fuel that may be used. It is, however, fully possible to press for the installation of appliances that even if they are in part used for smoke-producing coal for the time being, can be used without alteration and at any time for smokeless fuels.

The housing programme now starting thus affords a unique opportunity for not only less smoke from the beginning, but the means for complete smokelessness when conditions permit. It is most satisfactory that research and development during the last few years should have resulted in the production of new types of domestic appliance that, in addition to greater efficiency, make possible the use of all classes of solid fuel. This work has been carried out by a number of organisations and individuals, all working to ends which, though perhaps different in some respects, have had a great deal in common. The appliances, which it is not necessary to catalogue in detail, may all be regarded as suitable for the ultimate objective of burning smokeless fuel only. Some, by reason of their general efficiency and characteristics, or because of specially designed features, will give reduced smoke emission if bituminous coal is used. Useful though this will be during the interim period when, in many cases, coal will perforce be used, the permanent use of bituminous coal cannot be accepted as a satisfactory alternative to smokeless fuel, for the use of which such fires are just as suitable as other types. It is improbable, from the nature of the problem, that a smokeless open fire can ever be achieved, and even then the use of coal in it would remain open to other objections.

The importance of utilizing to the full these new appliances for post-war housing was appreciated at an early stage by the Society, which as long ago as 1942 proposed the installation of improved open fires and other appliances in a memorandum to the Design of Dwellings Sub-Committee of the Central Housing Advisory Committee. In 1944 a deputation from the Society and the Greater London Advisory Council for Smoke Abatement was received by the then Minister of Health, Mr. H. U. Willink, at which it was urged that 'all-fuel' fires only should be installed in post-war houses. Later in 1944 the Government published the Housing Manual, in which a most welcome policy on domestic heating, including the installation of improved appliances was outlined, and the importance of smoke prevention was admirably stressed.

In a special communication to Housing Authorities in January this year the Society drew attention to the *Housing Manual* recommendations, quoting the relevant paragraphs and adding notes that it was hoped would be of practical

assistance. It has become apparent that a considerable number of local authorities are giving the matter close attention.

Thus suitable appliances had been developed and there was growing agreement, backed by Government recommendation, to install them in houses to be built by or for local authorities. Doubts then arose, however, as to whether sufficient progress was being made to enable full production to cope with the expected demand. Replies to questions in the House of Commons in June of this year (put by Mr. E. H. Keeling) showed that :

- (a) no action was being taken to ensure, by licensing of production or otherwise that the new appliances would be installed in privately built houses ;
- (b) the approval by the Minister of Health of housing schemes submitted by local authorities would not at present be withheld if provision was not made for the improved appliances ;
- (c) the production of pre-war designs of inferior efficiency would have to continue for some time, although the speedy manufacture of the new types was being encouraged.

From these replies it was clear that conditions had not been attained by which an adequate supply of new appliances could be ensured, that obsolete pre-war appliances were to continue to be made and therefore to be installed in new houses, and that no action to prevent the installation of such obsolete appliances by local authorities or private builders was to be expected.

To a further question put by Mr. Keeling a reply on behalf of the Minister of Fuel and Power was important and illuminating. It was stated that if in the four million projected new houses the new appliances were installed instead of those of pre-war design, the saving in fuel would be of the order of four million tons a year — that is, of course, with similar heating standards in both cases. In other words, houses equipped with pre-war appliances would require an extra ton of fuel a year, which at present prices would be equivalent to raising the real rent of the house by about 1s. 6d. per week, or £4 a year — more than the total cost of some of the new grates.

In view of the unsatisfactory nature of the replies a critical resolution was passed by the Executive Committee of the Society and forwarded to the Ministries of Health, Fuel and Power and Works — about the time, as it happened, of the change of Government. It was also sent for information to Housing Authorities and to the Press.

The problem is essentially how to produce sufficient suitable appliances at a rate equal to that of house building and to make certain that they are installed in all the new houses. The mass production and concentration upon the most readily constructed types may be required, and it is possible that some measure of Government assistance and co-ordination may be necessary. The problem must be regarded as one of urgency that may well call for very determined action. The Executive Committee are seriously concerned about the grave danger of losing such a magnificent opportunity, not only for smoke prevention, but for raising by a substantial extent the deplorably low standards of domestic heating in this country. This meeting must be regarded as a forum for discussion on a specific and urgent matter, and not as a conference on domestic heating or smoke abatement in general terms. In view of the short time available it is hoped that contributions to the discussion will be limited to the one specific question, and it is suggested that the most constructive contributions will help to answer the following questions :

- (1) Can those representing the manufacturers of appliances tell us what the production position is to-day, and what difficulties and obstacles still remain ?
- (2) Can the representatives of local authorities say what action is being taken in their own areas, and what information or assistance they require ?
- (3) What steps can be taken by the Society or by others to help in the solution to the problem ?
- (4) What is, and what is it considered should be, the policy of the Government, and what further action should it be asked to take ?
- (5) What action should be taken to stimulate indifferent local authorities, private builders, and architects ?

Discussion

C. W. Gibson, M.P. (London County Council ; Vice-Chairman, Greater London Advisory Council for Smoke Abatement) said : The problem is to get a grate which tenants will find economical of fuel while reducing the smoke nuisance and will not give the local authority a burdensome capital cost. The L.C.C. has conducted an experiment on one of its estates in the use of smokeless fuel grates. In 1938-9 it installed 400 gas-ignited coke-burning grates. In 1943 a careful and special check was made in one block of flats and out of 50 tenants only one had anything to say in favour of the experiment.

Some complained of poor heating, some of coke fumes, many had ceased using the gas lighter and were using wood.

In my view what is needed is a fire grate which will be cosy and comfortable to look at and sit around, and yet will reduce or abolish the smoke nuisance.

E. H. Keeling, M.C., M.P. (Westminster City Council ; Chairman, Greater London Advisory Council for Smoke Abatement) asked the Parliamentary Secretary the following questions : (1) Can he give any estimate of the number of the bad old types of grates it will be necessary to put into new houses ? (2) The Minister of Works considers this to be no longer his business, and for all practical purposes it is that of the Minister of Health, who has taken to himself a much greater responsibility. Is the Ministry of Health therefore prepared to throw its weight about in the question ? Is it prepared to impose its will on the Ministry of Works ? (3) What steps has the Ministry taken to stimulate the production of the excellent new types of grate ?

Charles Gandy (Chairman, National Smoke Abatement Society) asked Alderman Key the meaning of the phrase he had used, "smoke reduction." The Society considered that the mere reduction of smoke, such as might be obtained by the continued use of bituminous coal in some improved types of open fire, to be inadequate in view of the fact that complete prevention of smoke was now practicable.

The production of fuel-burning appliances compared with the production of houses was in something like the same ratio as the production of dog collars to that of dogs. The matter was a mere detail in the immensity of the housing problem itself.

Alderman W. Barrett (Bath) expressed his disappointment at the lack of progress that had been made during the last thirty years, as revealed by Alderman Key's address.

Major H. J. Gillespie (Coal Utilisation Joint Council) suggested that there were three main directions in which the National Smoke Abatement Society could support the C.U.J.C.'s efforts towards practical smoke reduction. He described what was being done by the Council to bring to the notice of Local Authorities, architects and builders the advantages of the latest designs of solid fuel-burning equipment and he suggested that the Society should take every opportunity to support this publicity for improved appliances.

Secondly, he said that it was necessary to bring home to the authorities concerned, the advantage to be gained by spending a little more money on the first cost of the appliance. More efficient appliances were necessarily a little more expensive than older types, but on an actuarial basis, the capital cost of an appliance that saved only 25s. worth of fuel in a year could be raised by £10, assuming a ten-year life for that appliance.

Finally, Major Gillespie urged that representations should be made to the Government to make available more labour for ironfounders. Shortage of labour was causing a serious bottle-neck in the supply of new equipment.

J. W. Beaumont (Halifax) regretted Alderman Key's statement, made as it was on behalf of the Ministry responsible for the *Housing Manual*. He urged the organization of working exhibitions of the new appliances in all parts of the country.

Leslie Hardern (British Gas Council) said : I propose to deal with, not what may be done, but what in fact can be and has been done. It is now nearly eight years since we built the first smokeless estate in this country. I refer to Kensal House, where we provided the tenants with a gas ignited coke fire in their living rooms, gas fires in their bedrooms, an instantaneous gas water heater to serve the

kitchen sink and the bath, a gas cooker and a gas copper. For this smokeless fuel service, which is infinitely better than anything they had ever had before, the tenants are actually paying smaller weekly fuel bills. The chimneys have never been swept since the estate was built, yet you can go up on the roof, and push your arm down them, without finding any soot.

In the Government's demonstration houses at Northolt, we were given the opportunity of installing smokeless equipment in two of the houses. We were able to take advantage of the considerable developments which had taken place in smokeless equipment just before and during the war. To meet the varying conditions up and down the country, we arranged one as a gas and coke house and the other as a gas house. In the gas and coke house we installed one of the new Fulham coke fires in the living room, a coke boiler for winter water heating, a gas circulator for summer water heating, gas fires in the bedrooms, a gas radiator in the hall, and in the kitchen a gas cooker, sink heater, washing machine, and refrigerator. In the gas house, there was a new type of convector fire in the living room and the dining annex, and a built in multipoint water heater for all the year round hot water, the rest of the equipment being similar to the gas and coke house. I would like to stress the great flexibility in the gas and coke house, where the heating and hot water equipment could be used for any type of solid fuel.

As a result of these and other installations, the British Gas Council has been able to print a booklet called *The Fuel Services in the Post War Home* which describes the smokeless equipment already available.

There is no question, therefore, of waiting for suitable equipment to be designed. The only question is whether it can be produced in sufficient quantities at reasonable prices. I challenge the statement of the Parliamentary Secretary that there must be a gap between the production of new houses and the provision of smokeless equipment. If the Government will place the orders now, I am convinced that the manufacturers can produce the smokeless equipment faster than the builders can erect the houses. The capacity and the materials are available, but the Ministry of Labour and Directorate of Housing Fitments of the Ministry of Supply must assist in the provision of the necessary labour.

Possibly the Parliamentary Secretary was referring to the production of fuel equipment for all purposes — for renovations in existing houses as well as for installations in new houses. It is likely that there would not be sufficient smokeless equipment for both, but we are concerned to-day with new houses only, and we would have to reconcile ourselves to smoke producing equipment continuing to be installed in existing houses.

For new houses, however, suitable equipment has been designed, the patterns are ready, the materials and plant capacity are available, and the prices are reasonable. If the Ministry of Health will give a lead in the ordering of suitable equipment and the Ministry of Labour will support the manufacturers, the supplies of smokeless equipment will more than keep pace with the erection of new houses.

As regards prices, I am not speaking of expensive equipment. The price of the Fulham fire, for instance, is in the neighbourhood of 45s. 0d. The cheapest old-fashioned stool grates, which burn raw coal most inefficiently, could cost at the outside only about 17s. 0d. less, and what is that in relation to the present day prices of houses.

Mrs. Irene T. Barclay, B.A., F.S.I. (Women's Advisory Committee on Solid Fuel) said: This meeting should send a resolution to all the appropriate Ministries asking for the demobilisation of skilled tool-makers and moulders, and for immediate action to expedite the turn-over from the production of war material to the production of modern heating appliances. Excellent economical, pleasant smoke-reducing and smoke-eliminating appliances have been invented. Only by Government action will these grates, which housewives demand, find their way into our new houses.

Dr. F. J. Eaton (Gas Light and Coke Company) said: As there are many here to-day who will wish to take part in this discussion I will confine my remarks to the subject of the new solid fuel appliances. I share with previous speakers the disappointment which I am sure was felt by all when Alderman Key said that many of the new houses would have to be fitted with the older and less efficient appliances.

There is in this country a fuel problem which is almost as urgent as the housing problem and it is of the utmost importance that we should do all in our power to see that the new appliances which can burn any solid fuel are fixed in the new houses. All who have seen the temporary houses cannot but be impressed by the fuel burning equipment and the planning of the heat services. New appliances were found for these temporary houses. Why can't the supply be maintained?

The Ministry of Fuel and Power have stated that all solid fuel appliances should burn efficiently any solid fuel, but so far as I am aware no steps appear to have been taken to enforce this principle. It is true that the British Standards Institution have at the request of the Ministry of Works prepared specifications to which all solid fuel burning appliances must conform but, because the terms of reference stated that the appliances must be available at once, most of the specifications have an escape clause to the effect that existing types can be supplied until such time as patterns can be altered. Most of these specifications were drafted some six months ago. Much progress has been made and the present position is that many manufacturers have their new designs ready and what is needed is the supply of labour and materials which would be required, in any case, to make the older and less efficient appliances which we have just been told are to be installed.

In his speech yesterday, the Minister of Health charged the Local Authorities with the task of providing the houses we need. There are many representatives of Local Authorities here to-day and it is to them we must look for the installation of the more efficient appliances we all want.

Councillor J. W. Simpson (Lambeth) appealed to the conference not to make the discussion one of electricity versus all other fuels. In Lambeth there was a block of flats erected essentially as 'all-electric' in which the tenants were now using gaseous fuels. Something has to be left to the tenants, in the name of freedom and democratic privilege.

He asked the Conference to consider the matters arising out of Alderman Key's address, in the light of practical politics. He agreed with Alderman Key. As a member of a Civil Defence Emergency Committee, and of a Finance Committee, he could say with truth that smokeless appliances were not available at the present time; in fact many people in the bomb-damaged, now repaired houses, were waiting from six weeks to three months for ordinary domestic appliances. Nor would he lend himself to the principle of houses or appurtenances at any price. Quoting the example of the proposed new building in Lambeth, he said that all Local Authorities were faced with the problem of deficit in regard to new housing comparing economic rent as 1939, and the subsidies at present allowed.

If the economics of the public supply corporations were a difficulty he thought that those would soon be taken in hand by the public utilities themselves. In considering the problem of domestic smoke abatement in new houses the Society had to appreciate all the difficulties outlined by Alderman Key, and keep them to the fore. The first duty of an elected representative to a local authority was to watch the expenditure of the rate, in the general interest, coupled with the preservation of the elementary civic rights of the electors. The laying down of conditions at the present time was in his submission far from practical.

Mrs. E. G. Harrison, F.R.I.B.A. said she wished to endorse what had been said by Mrs. Barclay. Speaking as an architect it was, in her view, imperative that local authorities, architects, surveyors and members of housing committees should be aware of the new smoke-reducing, fuel-conserving appliances developed by recent research. The time had come when the decision had to be made as to what type of equipment was suitable for the provision of heating, cooking and hot water *before* the plans of houses were made final, for two reasons: (a) living conditions and area; (b) expenditure by the tenant for those services in relation to income.

Planning round efficient equipment was now essential. The equipment was only efficient if the tenants could afford to use it. Appliances placed in houses in a haphazard manner did not answer the problem of providing the public with good standard, workable subsidised houses.

Councillor E. Purser (Chairman Public Health Committee, Nottingham) suggested that the education towards the smokeless combustion of fuel should begin with the schools as it was difficult to get older people away from the liking of the blaze of a coal fire.

Councillor Mrs. H. Cobbett (Merton and Morden) referred to the second question in the Executive Committee's statement and quoted an extract from the minutes of the Housing Committee of her authority, relating to the building of 30 council houses : " Stove — The living room stove to be provided is of the new slow combustion type, which will burn alternative fuels, and in addition to providing hot water, will warm the ground floor rooms by convected heat." They contemplated building about 500 houses and consideration would certainly be given to the provision of similar types of stove.

R. E. L. Cleaver (Ministry of Fuel and Power), referring to a previous speaker's remarks, said he was sure Mr. Shinwell would like him to counter any suggestion that the Ministry of Fuel and Power were not interested in the smoke abatement problem. The proceedings of the conference would be studied with keen interest in the Ministry. The Minister was in close co-operation with the Minister of Health and would do everything he possibly could to help find the answer to this problem.

W. E. Weir (Preston) referred to an interpolation by Alderman Key in the course of his statement to the effect that he saw no reason why local authorities should not replace obsolete types of grates in Council houses when new and improved grates became available. It was perfectly clear from Alderman Key's address that the majority of the new houses to be built will have the old type of grate fitted. Since grates must be provided and we had been informed by one speaker that improved types were now available at low cost, it seemed to him that the Parliamentary Secretary's statements regarding lack of labour and materials, and his suggestion that replacements could be made later on, did not make sense.

As he had said, grates must be provided in the new houses, therefore, if it was a question of lack of materials, this could be settled by a grate manufacturer giving the quantity of metal required for an obsolete type and that required for a type approved by the Society ; the labour required in their making could also be compared, and if these comparisons indicated little difference in cost and time in production then there was no argument in favour of making and fitting obsolete types in new houses except that manufacturers wish to clear stocks now on hand.

When the Parliamentary Secretary referred to replacing obsolete types of grates he wondered if he had in mind Council houses built since the last war in addition to those to be built in the immediate future ?

Alderman E. A. Rigg (Leyton) considered that Alderman Key had presented the views of the Ministry and not his own, and that, further, as it was a Ministry of ' Health ' it should do everything in its power to abate the smoke nuisance, which was inimical to the health of the people. - Furthermore, as bottlenecks in war production were speedily overcome, housing, including smoke abatement appliances, in view of its urgency, should be treated similarly, and if necessary in the Royal Ordnance factories.

Mrs. E. Murphy (Women's Gas Council) said it was not so long ago that a cockney plumber called in to advise on the heating of a house told the housewife not to bother with the rest of the house, but to heat the hall, and he explained it in these words : " You see Mum, if you 'eat the 'all of the 'ouse, you 'eat the 'ole of the 'ouse." Mrs. Murphy hoped that we had progressed a little from that stage and that new houses would be planned to avoid unnecessary labour. No one would deny that we all wanted more comfort in the home, but at the same time we all wanted less work ; that was the problem which local authorities, architects, and all concerned with housing had to solve. It was not only a question of low capital cost, low maintenance cost and low running cost of fuel equipment. There was overwhelming evidence that when there was a little extra money in the home, it was spent on lessening the housewife's labour. In houses equipped by local authorities with coal-burning cooking ranges, gas cookers had been bought on hire purchase by the tenants. Gas coppers also, to save the trouble of lighting coal-fired coppers. Portable gas fires had been fitted in kitchen-living rooms to save lighting coal fires in the early morning. Small gas water heaters were used for washing-up and so on. Then there was the domestic servant problem. People who looked ahead accepted the position that in future cooks and domestic helps would be able to sell their services at hourly rates. This meant that every housewife would look after her own home with the aid of the most-up-to-date mechanical

devices with a view to economy in labour, whether it be her own labour, or paid labour. Mrs. Murphy ended by appealing to all concerned with housing to keep the labour saving point of view well in mind.

E. L. Leeming (Surveyor, Urmston (Lancs.) U.D.C.) referred to the question raised previously by a lady speaker as to the shortage of labour in foundry work. It was a fact that no new labour was entering this industry; certainly young people would not consider it since the conditions of employment and pay were thoroughly unsatisfactory for such strenuous and disagreeable work. This was likely to hold up the production of castings, including appliances for Smoke Abatement. Would it not be worth while employing German Prisoner-of-War labour in this industry in order to expedite the production of houses?

The question of district heating had barely been mentioned in the Conference. The Urmston Authority were considering a proposal for district heating on a scheme comprising 1,300 houses, together with public buildings. It was hoped that the Ministry of Health would sanction the scheme, but in any case it was worth noting that the Ministry of Fuel and Power would give strongest possible backing to proposals for district heating on the grounds of fuel economy, and fuel economy means Smoke Abatement. It is not often realised that there is a strong connection between fuel economy and the export trade. Every ton of coal saved is a ton saved for export and we must export to live.

H. G. Clinch (Housing Officer, West Ham) said: I rise to refute the statement that there are large stocks of old type fireplaces to be used up; as a War Damage Officer responsible for colossal works of repair, I can assure you that there are no such stocks available.

Do let us be sensible and adhere to the facts of the situation, and what are the facts?

Are there sufficient supplies of solid smokeless fuels available at the present time and will there be sufficient for some considerable time to come? The answer is *no*.

Has a grate been evolved which will burn efficiently both smokeless fuel and bituminous coal? The answer is *yes*!

Will such grates cost any more to manufacture than the old type and the answer is *no*!

Then — the practical and sensible thing to do is to request the Ministry of Health to require local authorities to install these grates in their new houses so that all available smokeless fuel may be used by the occupiers both now and in the future. I suggest that the Society proceed on these lines.

Other contributions to the discussion were made by J. Ratcliffe (Willesden), Councillor W. Taylor, J.P. (Deptford), Alderman Trueman (Barnsley), E. H. Gray (Leyton), Councillor T. R. Thirtle (Uxbridge), Alderman Mrs. Evans (Dagenham) and others.

Resolution

After considerable discussion on a suitable resolution to express the views of the meeting, the following was proposed by Mr. Keeling, seconded, and carried:

THAT in the interests of the Public Health, this meeting of the National Smoke Abatement Society requests the Executive Committee to inform the Minister of Health of the views of the meeting and on the installation of improved fuel-burning appliances, in new houses, and to ask him to receive a deputation.

Following an informal expression of thanks to the Chairman, to Alderman Key and to those who had contributed to the discussion, the meeting was declared closed.

Subsequent Action

In accordance with the resolution passed at the meeting the Minister of Health was requested to receive a small deputation from the Society. With this letter the following notes were submitted :

In accordance with a resolution passed at the meeting on 19th October, convened by the Society, which was opened by the Parliamentary Secretary to the Ministry of Health, the following preliminary observations are submitted.

(1) These observations and the Society's other recent representations refer solely to the appliances to be installed in new houses. They do not involve in any way the further question of the replacement of old by new appliances in existing houses, a reform which, though important, can for the present be deferred. Nor are they concerned with the question of the fuel to be used in the new appliances, which again is a subject for future consideration. The essential points we wish to stress are that the improved appliances suitable for the burning of smokeless fuels should be installed (a) to give immediate fuel economy (with some reduction of smoke), and (b) to make possible without further changes and expenditure the future progressive change to smokeless usage that all are agreed is desirable.

(2) It is understood that there are no considerable stocks of the pre-war appliances of the types now obsolete. Some of the most suitable new types are of simple design, and once production of these is under way there need be no significant difference in the rate of supply. Obviously, one type or other *must* be manufactured, at approximately the same rate as the houses are completed.

(3) Some of the new appliances are already being manufactured, if only to a limited extent. The degree to which production can be safely increased appears to depend almost entirely on the expressed policy of the Government. We understand that one firm alone estimates that it could supply one-third of the appliances for all the new houses likely to be built in the near future.

(4) Some new appliances, to which a certain prominence has been given, may not yet be ready for commercial production, and it is conceivable that an impression exists that because of this the effective action required should be postponed until these are ready. If such a view — admittedly only hypothetical — should in fact exist, we would deprecate it. Such appliances, if approved, can come later, and it is likely that still more improvements will continue to be introduced as time goes on, so that there will be no finality in the situation. We urge the fullest use *now* of what can *now* be made available in quantity. The question may be compared with that of tank production in the early stages of the war.

(5) It is conceivable also that reports, trials, and comparisons of the new appliances have not been completed in final detail. Even if this should be the case there is no doubt whatever that the appliances are considerably superior to the alternatives that must otherwise be used, and this, we submit, is the over-riding factor.

(6) Reference may be made to the statement read at the recent meeting on behalf of the Executive Committee, and to the resolution on the subject passed as a result of questions asked in the House of Commons in June last, copies of which are attached.

(7) These are preliminary observations, but they are sent now because of the intense anxiety expressed at the meeting that the opportunity which now offers, to ensure in all new houses better standards of domestic heating, should not be lost ; as would be the case if the Government failed to act promptly and to give the lead for which local authorities, we are satisfied, are looking to receive.

In reply to the request the following letter was received from the Minister's Private Secretary :

Mr. Bevan asks me to say that he has very carefully considered the request in your letter of the 12th November that he should receive a deputation from the Society. He very much regrets, however, that owing to the extremely heavy pressure of other Parliamentary and Departmental business at present he does not see his way to doing this. He will, however, give close attention to the points raised in your letter.

New and Recent Publications

Joint Conference Report—Report of joint conference with the Institute of Fuel, 23rd February, 1945. 8 Papers and discussions. 45,000 words.
2/6 each.

Domestic Fuel Efficiency and Smoke Prevention—Report of joint conference with the N.W. Section, Institute of Fuel, Manchester, 14th November, 1945. Papers by Dr. G. E. Foxwell, Charles Gandy, and Arnold Marsh, and discussion.
Ready shortly, 1/- each.

The Smoke Problem and Science Teaching—A booklet for science teachers, with notes and experiments. Just published. 3d. each ; 2/6 per dozen.

Smoke Control—Suggestions to Local Authorities on Guidance and Control in respect to new fuel burning installations. Just published.
3d. each ; 2/6 per dozen.

Constitution—The new constitution of the Society in booklet form. 2d. each.

Also

Plan for Clean Air—A popular “quiz” 2d. each.

No Clean City—*Why* smoke prevention is necessary in post-war reconstruction. 2d. each.

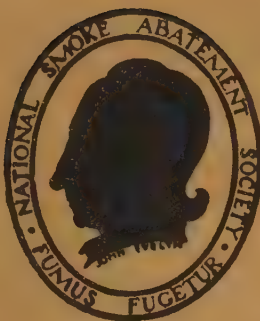
Steer's Law of Smoke Nuisances—
1/- paper ; 2/6 cloth-bound.

Annual Report, 1945—(Ready March, 1946) 2d. each.

All Prices include Postage

National Smoke Abatement Society

Chandos House, Buckingham Gate, Westminster, S.W.1



**NATIONAL SMOKE
ABATEMENT SOCIETY**

Programme of the

**Annual General Meeting
and Joint Conference
with the Institute of Fuel**

22nd and 23rd February, 1945



**ANNUAL GENERAL MEETING *at the*
CAXTON HALL, WESTMINSTER, S.W.1**

**CONFERENCE *at the* INSTITUTE OF
ELECTRICAL ENGINEERS, SAVOY PLACE, W.C.2**

SALE 0414 11/31/1

Programme



Thursday, 22nd February, 1945.

2.30 p.m., at the Caxton Hall, Caxton Street,
Westminster, S.W.1.

Annual General Meeting

AGENDA

1. To adopt the Minutes of the previous meeting.
2. To receive the Annual Report.
3. To receive the Annual Statement of Accounts.
4. Election of :
 - (a) President.
 - (b) Vice-Presidents.
 - (c) Honorary Treasurer.
 - (d) Elected Members of the Council.
 - (e) Executive Committee.
5. Any further business.*

* Resolutions for the consideration of the Annual General Meeting may be submitted by any member or representative of an affiliated Local Authority or other member. It is requested that such resolutions be sent to the Secretary not later than 5th February, 1945.

Please return before 5th February, 1945.

REPLY FORM

To the General Secretary,
National Smoke Abatement Society,
Chandos House,
Buckingham Gate, London, S.W.1.

I hope to attend the Annual General Meeting of the Society on Thursday, February 22nd, and the Joint Conference with the Institute of Fuel on Friday, 23rd February, 1945.

Please forward pre-prints of the Papers in due course.

I enclose Conference Fee of 10s. 6d.

Signed

Address

Representing

Friday, 23rd February, 1945.

At the Institution of Electrical Engineers,
Savoy Place, Victoria Embankment, London,
W.C.2.

Joint Conference with the Institute of Fuel

10 a.m. Morning Session : **The Problem**

Chairman : Sir Lawrence Chubb,
Hon. Treasurer, National Smoke
Abatement Society

- (1) **Opening of Conference and Short Address by Major the Rt. Hon. Gwilym Lloyd George, M.P., Minister of Fuel and Power.**
- (2) A Statement of the Problem. By G. M. B. Dobson, D.Sc., F.R.S. (Chairman, Atmospheric Pollution Research Committee).
- (3) The Effects on Civilisation of Atmospheric Pollution. By Major S. F. Markham, M.P., M.A., B.Litt.
- (4) Discussion.

12 noon. Adjournment for lunch.

1.30 p.m. **Afternoon Session : The Prevention of Pollution.**

Chairman : Dr. E. W. Smith,
President of the Institute of Fuel.

- (5) Small Scale Steam Raising Plant. By S. N. Duguid, B.Sc.Tech., F.Inst.F., F.R.San.I.
- (6) Grit and Smoke from Power Stations. By John Bruce, A.M.I.E.E., F.Inst.F.
- (7) Industrial Furnaces. By Dr. R. J. Sarjant, M.Sc., A.R.C.S.
- (8) Kilns and Pottery Furnaces. By A. T. Green, F.I.C.
- (9) Domestic Smoke. By A. Blackie, M.A., F.Inst.P. (of the Fuel Research Station).
- (10) Railway Smoke. By M. G. Bennett.
- (11) Discussion.
- (12) A summing-up and conclusions by the Chairman.

4.30 p.m. Close of Conference.

Notes and Information

Conference Fee

A fee of 10s. 6d. per member or delegate will be charged to defray some of the expenses incurred in arranging the conference and printing the **Proceedings**.

Reply

A Reply Form is enclosed (except to delegates already appointed by Local Authorities and other bodies). Those attending are requested to return this form as soon as possible and not later than Monday, February 5th.

Papers

The papers will not be read in full at the Conference and pre-prints will be sent to all from whom the reply form is received.

Proceedings

A full report of the Discussions will subsequently be published and a copy sent to all members of the Conference. Further copies of Papers and Discussions will be available at 2s. 6d. per set.

Meeting Places

Please note that the Annual General Meeting on Thursday afternoon, February 22nd, will be held at the **Caxton Hall**, and the Conference on the following day, February 23rd, at the **Institution of Electrical Engineers**.

ARNOLD MARSH,

General Secretary.

National Smoke Abatement Society,
Chandos House,
Buckingham Gate,
Westminster, S.W.1.

Tel. : ABBey 1359.